TEMBER 1960
E 3 ● NUMBER 9

- Lax & Button — Electromagnetic Properties of Ferrimagnetics and their Applications from UHF to Millimeter Waves — Part I
- Miller — The Traveling Wave Resonator and High Power Microwave Testing
- Clayton & Hollis — Calculation of Microwave Antenna Radiation Patterns by the Fourier Integral Method
- Booth & Veltrop — Detection and Measurement of Spurious Signals Generated by Microwave Oscillator Tubes

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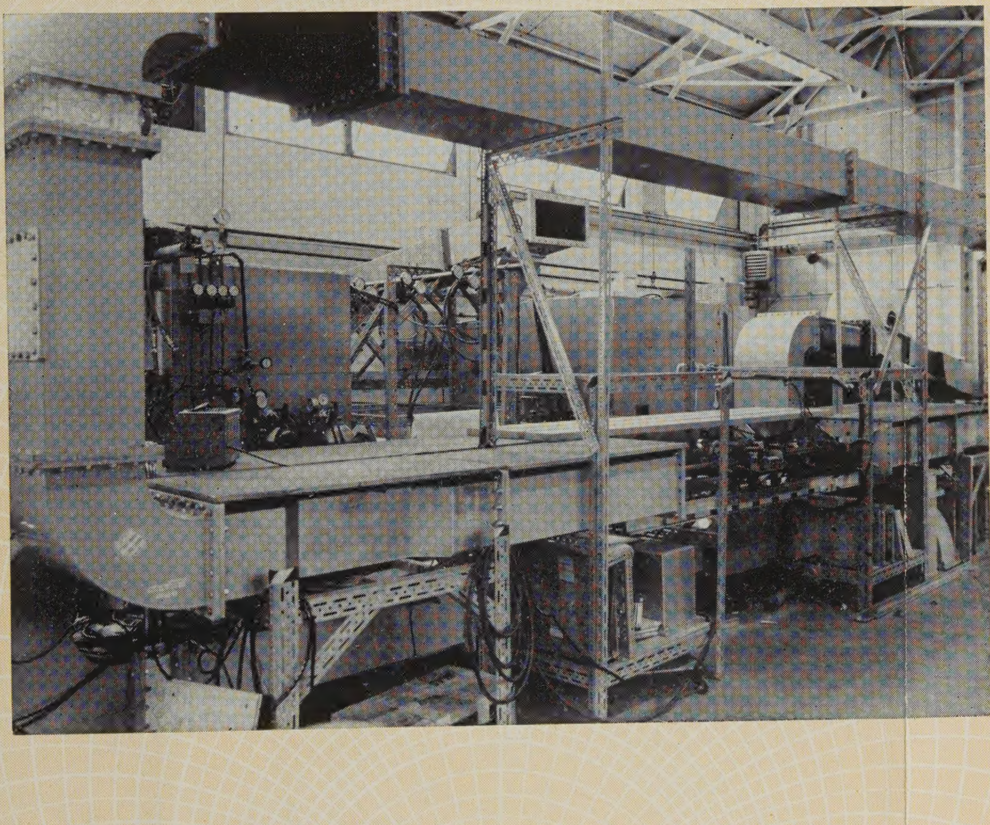

Starting In This Issue

ERRIMAGNETICS AND THEIR APPLICATIONS

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CLearwater 9-8162
TWX: BS 1393

South Lincoln Shopping Center
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Affiliate
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4134 Del Rey Avenue
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Telephone: EXmont 8-1072

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REPRESENTATIVES

MICROWAVE ELECTRONIC INSTRUMENTS

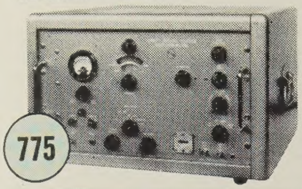
By

FXR, Inc.

FXR

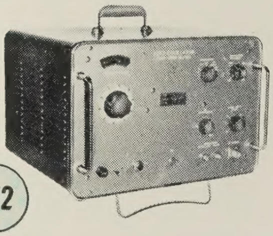
SWEEP SIGNAL SOURCE

- Frequency Range: 8200 to 12400 Mc.
- Power Output: Adjustable 0 to 10 MW min.
- Sweep Rate: Linear with time —300 Mc to 300 K Mc.
- Sweep Range: Continuously adjustable 0-4.2 K Mc.
- Direct reading dial settings for upper & lower frequencies.
- Modulation: Square wave 800 to 1200 cps.
- Provisions for A.G.C.


775

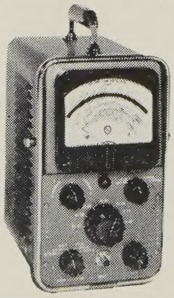
SIGNAL SOURCES

- Model L771B: 950 to 2000 MC.
- Model S771B: 1900 to 4000 MC.
- Model C772A: 3950 to 8200 MC.
- Model X772A: 7000 to 11,000 MC.
- Power Output: 10-100 MW CW, MAX into matched load. Variable through level-set attenuator.
- Modulation: pulse, square wave both internal and external.


772

STANDING WAVE AMPLIFIER

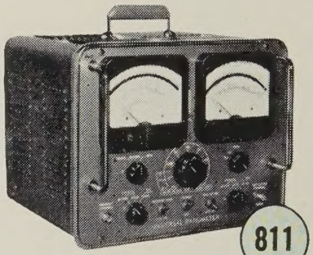
- A 5-inch removable meter with 1% linearity provides high resolution and accuracy.
- A filter, tunable between 950 and 1050 CPS, aligns instrument with output frequency of signal source.
- Range: 70 DB in six decade steps. Normal and expanded scales for VSWR and DB.
- Gain automatically maintained when switching from normal to expanded scales.
- Detectors: crystal or bolometer.
- Full scale sensitivity, 0.1 μV: signal-to-noise ratio, 3:1.


812

UNIVERSAL RATIOMETER

RATIO METER AND
STANDING WAVE AMPLIFIER
IN ONE COMPACT PACKAGE

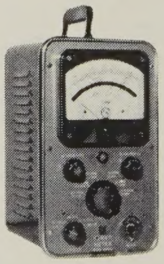
- Two-cycle Precision Logmeter VSWR reflectometer readings of 1.02 to ∞ on only two scales.
- VSWR, DB and reflection coefficient scales eliminate conversion tables.
- Full 70 DB standing wave amplifier operation, expanded VSWR scales.
- Crystal and bolometer operation.


811

TEMPERATURE COMPENSATED POWER METER

- Power Range, full Scale.
  —20 DBM or 0.010 MW.
  —15 DBM or 0.030 MW.
  —10 DBM or 0.10 MW.
  — 5 DBM or 0.30 MW.
  0 DBM or 1.00 MW.
  + 5 DBM or 3.00 MW.
- Maximum possible accumulative error ±3%.
- FXR Series 218 Temperature Compensated Thermistor Head a required accessory.

Note: Also available is the B832T, a battery powered transistorized power meter, with similar specifications.


831

UNIVERSAL KLYSTRON POWER SUPPLY

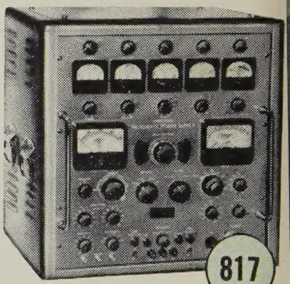
- Beam: 200 to 2000 V at 0 to 125 MA, 1800 to 3600 V, 100 MA, 250 W MAX.
- Control Grid: Pos. 0 to 150 V, Neg. 0 to 300 V.
- Reflector: 0 to 1000 V.
- Regulation: 0.01%.
- Ripple: 1 MV, RMS, MAX.
- Internal Modulation: pulse, sawtooth, square wave, sinewave.

815

UNIVERSAL MICROWAVE POWER SUPPLY

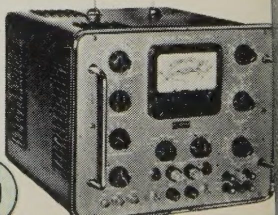
- Helix (beam): 0 to 1800 V, 0 to 100 MA; 1700 to 2500 V, 0 to 100 MA; 2500 to 3500 V, 250 W MAX.
- *Grid 1: 0-300 V DC, 0 to 5 MA.
- *Grid 2 (reflector): 0-1200 V DC, 0 to 1 MA.
- *Grid 3 (focusing electrode): 0 to 750 V DC, 0-1 MA.
- *Grid 4 (focusing electrode): 0 to 500 V DC, 0-1 MA.
- Collector: 0-300 V DC, 0-100 MA.
- *Anode: 0-600 V DC, 0-60 MA.
- Filament: 0-15 V DC, 0-3 AMP at 20 W MAX.
- Regulation: 0.005% Ripple: 3 MV.

**May be internally modulated: pulse, sawtooth, square wave, sinewave.*


817

KLYSTRON POWER SUPPLY

- Beam: 300-1000 V at 85 MA. Grid: —300 to —150 V at 0 to 5 MA. Built-in limiting resistor.
- Reflector: 0-900 V at 10-20 μA.
- Regulation: 1%.
- Internal Modulation: pulse, sawtooth, square wave.


819

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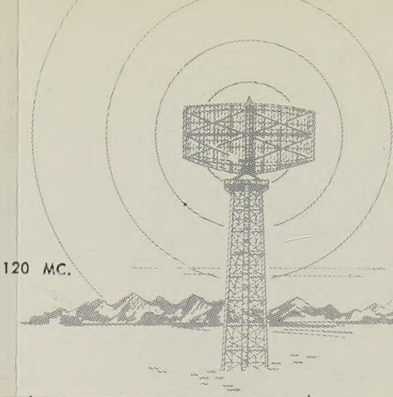
SHORT FORM CATALOG

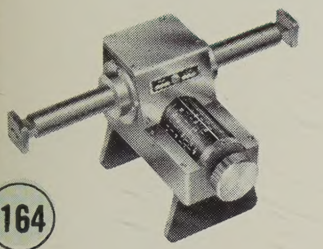
WR-2100 Components

DESIGNED FOR OPERATION
OVER THE FULL WAVEGUIDE BANDWIDTH
FROM 350 TO 530 MC

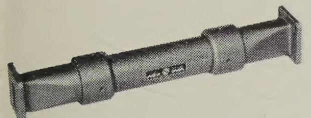
WR 975 components also available. Frequency range 750 to 1120 MC.



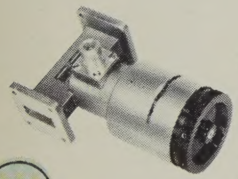
Wave Guide Test Equipment


164

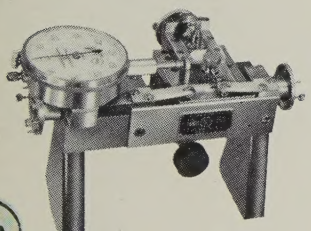
Direct Reading Precision Variable Attenuators


175

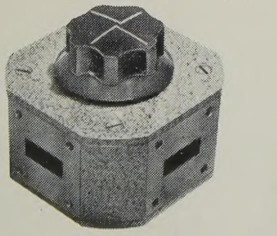
Fixed Precision Attenuators


410

Direct Reading Frequency Meters


103

Precision Slotted Sections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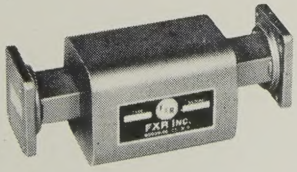
Wave Guide Switches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Ferrite Isolators

FXR SERIES PREFIX WAVEGUIDE SIZE * IN INCHES (I.D.)	J 21.00x10.50	L 6½x3¼	R 4.410x2.310	S 3x1½	H 2x1	1½
FREQUENCY RANGE IN KMC/SEC	0.35-0.53	1.12-1.70	1.70-2.60	2.60-3.95	3.95-5.85	5.85x
SLOTTED SECTIONS						
Fixed W.C.	J104A $2350	L101A $950	R101A $1340	S101A $445	H101A $385	S101A
Interchangeable W.C.					H115A $110	C115A
ATTENUATORS						
Flap		L150B $170	R150B $225	S151A $100	H151A $ 95	
Semiprecision				S155A $170	H155A $170	C155A
Precision Calibrated		L160B $575	R160B $500			
Precision Direct Reading				S164A $595	H164A $500	C164A
Fixed		L168A-E $215		(Models A-3DB, B-6DB, C-10DB, D-2		
Fixed Precision				S175A $365	H175A $240	C175A
40DB Step						
FERRITE ISOLATORS					H157A $270	C157A
CRYSTAL DETECTOR MOUNTS						
Tuneable						
Fixed						
MATCHED BOLOMETER MOUNTS				S207A $145	H207A $140	C207A
THERMISTOR MOUNTS		L216A $225	R216A $250	S216A $120	H215A $ 94	C216A
THERMISTOR HEADS TEMPERATURE COMPENSATED		L218A $350	R218A $350	S218A $225	H218A $180	C218A
TUNERS						
Slide screw		L310A $250	R310A $325	S311A $150	H311A $140	C311A
E/H				S312A $270	H312A $210	C312A
PRECISION PHASE SHIFTERS						
DIRECT READING FREQUENCY METERS						
Precision						C402A
Reaction					H410B $250	C410B
Reaction, micrometer						
Transmission						
TERMINATIONS						
Fixed	J501A $750	L501A $210	R501A $180	S501B $ 44	H501B $ 34	C501B
Sliding		L502A $350		S502A $ 95	H502A $ 70	C502A
High power						C505A
STANDARD MISMATCHES						
VSWR 1.00				S510A $500	H510A $420	C510A
VSWR 1.05				S510B $350	H510B $310	C510B
VSWR 1.10				S510C $290	H510C $250	C510C
VSWR 1.20				S510D $250	H510D $210	C510D
VSWR 1.50				S510E $350	H510E $310	C510E
WAVEGUIDE-TO-COAX ADAPTERS	J600BN $200 J600B $170	L600B $170	R601B $225	S601B $ 50	H601B $ 40	C601B
DIRECTIONAL COUPLERS						
Multihole				S610AD $370	H610A-D $240	C610A-D
Crossguide		L612E $300	R612E $250	S612D $140	H612D $120	C612D
WAVEGUIDE TEES						
Series		L620A $175	R620A $175	S620A $ 90	H620A $ 80	C620A
Shunt		L621A $175	R621A $175	S621A $ 90	H621A $ 80	C621A
Hybrid		L622A $220	R622A $220	S622A $110	H622A $ 95	C622A
WAVEGUIDE BENDS						
90° E-plane	J623B $420	L623B $125	R623B $150	S623B $ 90	H623B $ 65	C623B
90° H-plane	J624B $420	L624B $125		S624B $ 90	H624B $ 65	C624B
WAVEGUIDE 90° TWISTS				S625A $175	H625A $125	C625A
PRECISION SLIDING SHORTS		L630A $275		S630A $175	H630A $165	C630A
STRAIGHT WAVEGUIDE SECTIONS (Min. length)		L634A $110	R634A $110	S634A $ 75	H634A $ 50	C634A
STANDARD GAIN HORNS		L638A $350	R638A $500	S638A $ 75	H638A $150	C638A
WAVEGUIDE SWITCHES	Manual Electrical				H641A $350 H641AE $400	C641A C641AE
SHIELDED TUBE MOUNTS					H760A $150	
HARMONIC GENERATORS						
WAVEGUIDE STANDS		L911A $ 15		Z910A $ 7	Z910A $ 7	Z910A

NOTE:

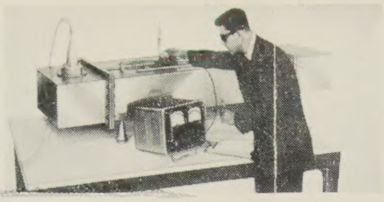
†Price will be furnished on request.
*Specify required flanges when ordering.
BIDIRECTIONAL COUPLERS available on special order.
WAVEGUIDE FLANGES and FLANGE SCREWS available.

Due to continuing product improvement, specifications and prices are subject to change without notice.
Prices indicated are domestic.

0.35 Kmc 0.75 Kmc 90 Kmc 220 Km

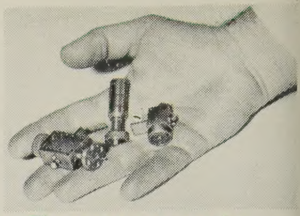
METER COMPONENTS

MILLIMETER COMPONENTS



Expanding both extremes of the microwave spectrum

MACRO-MICROWAVE AND MICRO-MICROWAVE
COMPONENTS AND INSTRUMENTATION.



2mm and 3mm Components

¼	W 1¼x⅝	X 1x½	Y .622x.311	K* .420x.170	U* .280x.140	Q .224x.112	M .148x.074	E 122x.061	F .080x.040	G .051x.0255
.20	7.05-10.00	8.20-12.40	12.40x18.00	18.00-26.50	26.50-40.00	33.00x50.00	50.00-75.00	60.00x90.00	90.00-140.00	140.00x220.00
$335	W101A $300	X101A $245	Y102A $545	K102A $545	U102A $545	Q103A $1100	M103A $995	E103A $1650	F105A $1400	G105A $1400
$110	W115A $110	X115A $ 90	Y115A -			TYPE Z116A CARRIAGE		$160		
						Q151A $110	M151A $100	E151A $190		
$ 95	W155A $ 85	X155A $ 75	Y155A $ 90	K155A $135	U155A $170					
									F163A $975	G163A $975
$350	W164A $350	X164A $270	Y164A $275	K164A $425	U164A $450	Q164A $825	M164A $800	E164A $1200		
DB, E-30DB)										
$135	W175A $115	X175A $ 95	Y175A $115	K175A $240	U175A $250	Q175A $475	M175A $425	E175A $675	(Values to 30DB)	
	W176A $185	X176A $165								
$245	W157A $245	X157A $220	Y157A $245	K157A $270						
			Y205B $175	K205B $175	U205B $200 U206B $200	Q206B $210	M208A $325 M206B $210	E208A $400 E206B $350	F208A $400	G208A $400
		X211A $ 54	Y212A $ 80	K212A $ 80	U212A $ 80					
$135	W207A $120	X207A $ 80								
$ 88	W216A $ 79	X216A $ 74	Y216A $110	K216A $150	U216S $270					
$170	W218A $150	X218A $145	Y218A $210	K218A $250	U218S $400					
$135	W311A $130	X311A $125	Y311A $130				M311A $195			
$180	W312A $150	X312A $130	Y312B $135	K312B $155	U312B $170	Q312B $235	M312B $245	E312B $390	F313A $775	G313A $775
									F314A $950	G314A $950
1275		X402A $1275								
$180	W410B $165	X410B $150	Y410A $210	K410A $230	U410A $250					
						Q410X $325	M410X $300	E410X $500	F412A $750	G412A $750 G413A $800
		X411A $175								
$ 30	W501B $ 25	X501B $ 24	Y501A $ 24	K501A $ 30	U501A $ 35	Q501A $ 95	M501A $ 90	E501A $150	F501A $150	G501A $150
$ 65	W502A $ 55	X502A $ 45	Y502A $ 50	K502A $ 70	U502A $ 75					
†	W505A $125	X505A †								
$390	W510A $370	X510A $360	Y510A $450	K510A $480	U510A $625					
$295	W510B $285	X510B $275	Y510B $325	K510B $340	U510B $525					
$235	W510C $225	X510C $215	Y510C $275	K510C $280	U510C $450					
$195	W510D $185	X510D $175	Y510D $225	K510D $240	U510D $280					
$295	W510E $285	X510E $275	Y510E $325	K510E $340	U510E $350					
$ 35	W601B $ 30	X601B $ 25								
$140	W610A-D $115	X610A-D $ 95	Y610A-D $100	K610A-D $165	U610A-D $185		M610A-D $500			
			Models A-3DB, B-6DB, C-10DB, D-20DB							
$ 85	W612D $ 75	X612D $ 50	Y612D $ 55	K612D $110				Models D-20DB, E-25DB		
$ 60	W620A $ 45	X620A $ 35	Y620A $ 40	K620A $ 45	U620A $ 55	Q620A $ 65	M620A $ 60	E620A $110	F620A $275	G620A $275
$ 60	W621A $ 45	X621A $ 35	Y621A $ 40	K621A $ 45	U621A $ 55	Q621A $ 65	M621A $ 60	E621A $110	F621A $275	G621A $275
$ 75	W622A $ 60	X622A $ 49	Y622A $ 54	K622A $ 65	U622A $ 80	Q622A $100	M622A $100	E622A $170	F622A $325	G622A $325
$ 45 $ 45	W623B $ 35 W624B $ 35	X623B $ 24 X624B $ 24	Y623B $ 32 Y624B $ 32	K623B $ 38 K624B $ 38	U623B $ 42 U624B $ 42	Q623B $ 55 Q624B $ 55	M623B $ 50 M624B $ 50	E623B $ 90 E624B $ 90	F623A $275 F624A $275	G623A $275 G624A $275
$ 75	W625A $ 65	X625A $ 40	Y625A $ 60	K625A $ 60	U625A $ 70	Q625A $100	M625A $100	E625A $100	F625A $100	G625A $100
$155	W630A $145	X630A $130	Y630B $145	K630B $155	U630B $150	Q630B $155	M630B $160	E630B $250	F631A $275	G631A $275
$ 38	W634A $ 35	X634A $ 30	Y634A $ 35	K634A $ 38	U634A $ 38	Q634A $ 50	M634A $ 50	E634A $ 50	F634A $ 85	G634A $ 85
$125	W638A $120	X638A $100	Y638A $125	K638A $150	U638A $175	Q638A $120	M638A $125	E638A $250	F638A $200	G638A $200
$300 $335	W641A $265 W641AE $290	X641A $225 X641AE $250	Y641A $250 Y641AE $275	K641A $275 K641AE $300	U641A $300 U641AE $325					
	W760A $130	X760A $130								
						Q780A $165	M780A $160	E780A $250	F781A $475	G781A $475
$ 7	Z910A $ 7	Z910A $ 7	Z910B $ 7	Z910B $ 7	Z910B $ 7	Z910C $ 7	Z910C $ 7	Z910C $ 7		

COMPLETE LINE MICROWAVE IN THE WORLD

FXR

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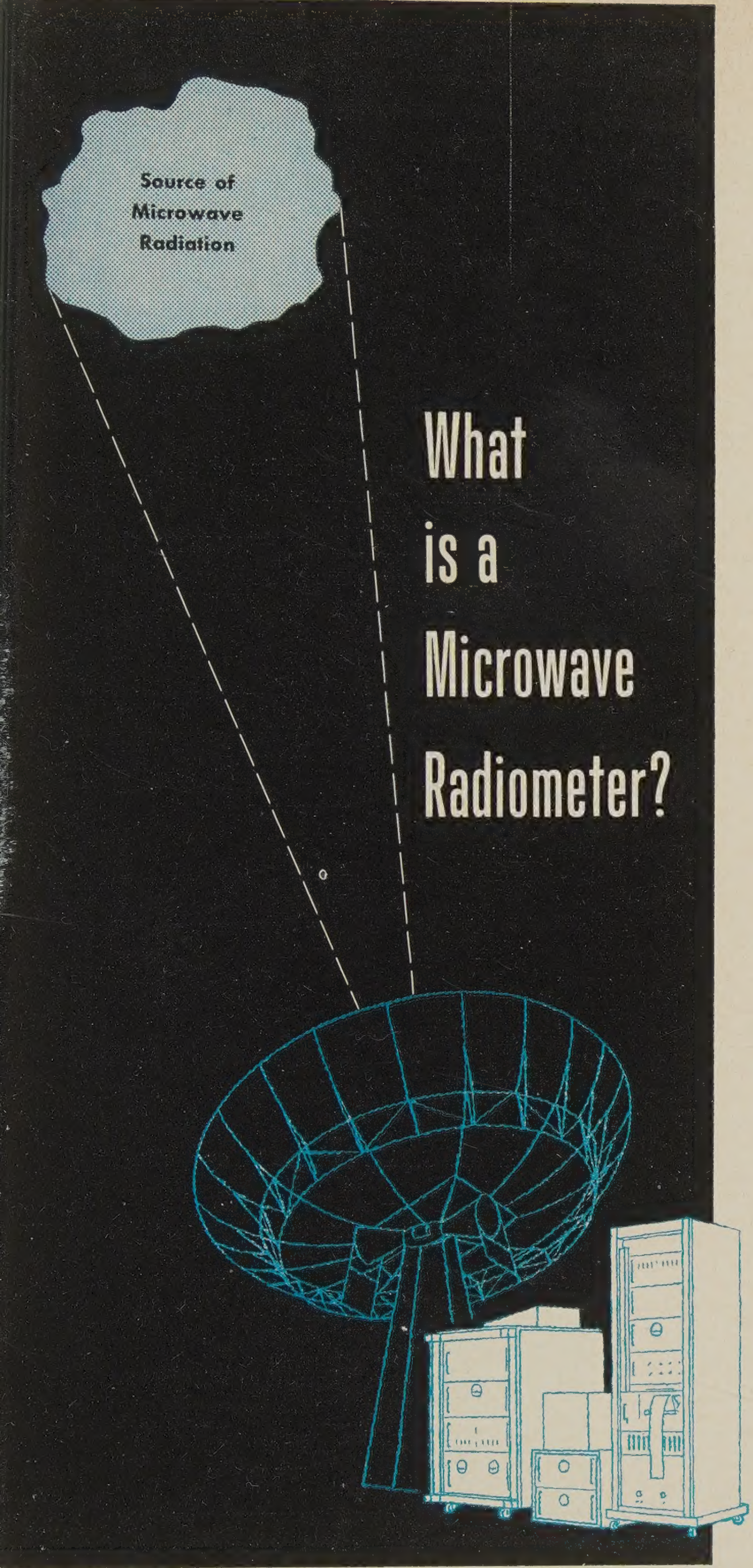
Budd-Stanley and FXR's L. I. C. plant facilities.



What is a Microwave Radiometer?

The fundamental ingredients of any microwave radiometer consist of an antenna, an amplifier, a detector, and an indicator. From a thermodynamic standpoint the antenna may be considered as a device which transports its radiation resistance at the input terminals of the receiver into a thermal reservoir contained within the volume of space "observed" by the antenna and determined by its directive characteristics. If we then assume that the observed medium is a composite black body reservoir at some temperature T, then the temperature of the radiation resistance of the antenna will come into equilibrium with the temperature of this reservoir. The amplifier portion of the receiver then amplifies the power presented to its input terminals by the radiation resistance. This power level is the well known Johnson noise power KTB where K is Boltzmann's constant, T is the equivalent temperature of the radiation resistance and B the predetection bandwidth of the amplifying device. The power input to the amplifier is then equivalent to the power output of a resistor matched to the receiver input, and immersed in a thermal reservoir at temperature T. Since this power level is directly proportional to the temperature of the reservoir, the signal input can be expressed in temperature units (of degrees Kelvin).

In the Rayleigh-Jeans approximation for the brightness of Planck radiation, the brightness per unit cycle is inversely proportional to the square of the wavelength, whereas Johnson noise power is independent of frequency and dependent only upon temperature. The thermodynamic balance of the two sources of power is obtained, in a receiving system, through the wavelength characteristic of the average antenna cross section. When performing the integration of the product of brightness per unit wavelength and antenna cross section, over the bandwidth of the receiver and the solid angle of the antenna aperture, the wavelength-dependent terms cancel. Hence an antenna totally "immersed" in a black body at temperature T will contribute a constant power output at its terminals, independent of frequency.

In summary, the logic is as follows: The power incident upon the antenna aperture within the bandwidth of the receiving system produces a thermal bath for the radiation resistance of the antenna, at the temperature of the "composite equivalent" black body viewed by the antenna. This antenna temperature is then transmitted to the amplifier via the "Johnson noise mechanism," where it is amplified in the presence of the noise power attributable to the man-made circuitry.

The signal strength is recorded in temperature units (degrees Kelvin).

Ewen Knight radiometers of the HII series are capable of detecting temperature changes at the receiver input terminals as low as 0.01°K, which is approximately 10^{-25} watts/cps.

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SEPTEMBER, '60 vol.3 - no.9

the microwave journal

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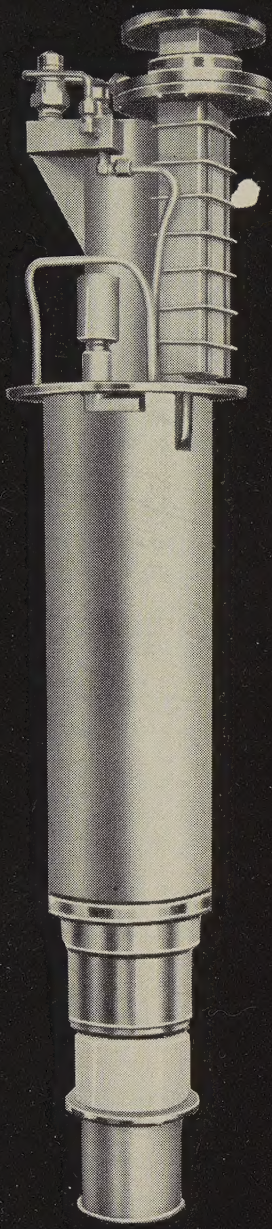
Conducting Fabric Antennas

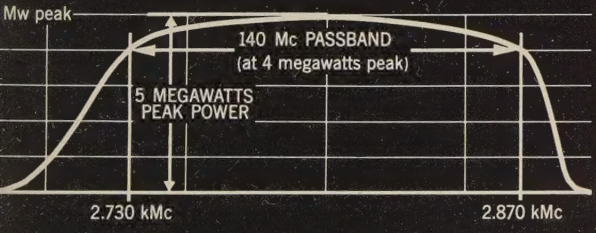
Millimeter Radiometers

"the microwave journal" is published monthly by Horizon House Inc., William Bazz President, Executive Editorial offices at 1330 Beacon Street, Brookline 46, Massach setts, telephone REgent 4-3220.

"the microwave journal" is issued without charge upon written request to qualified pe sons working at microwave frequencies in the fields of antennas and propagatio electrons and solid state devices, systems, and components manufacturers in the co tinental United States and Canada, including governmental and university installatior Other subscriptions — continental United States, $10 per year, single copy, $1 wh available. In Canada, $15 per year, single copy, $1.50 when available. Other forei countries, $20 per year, single copy, $2 when available. Copyright © September 1960 Horizon House — Microwave, Inc. Accepted as controlled circulation publication Boston, Mass.

Postmaster: Please send Form 3579 to "the microwave journal," 1330 Beacon Stree Brookline 46, Massachusetts.





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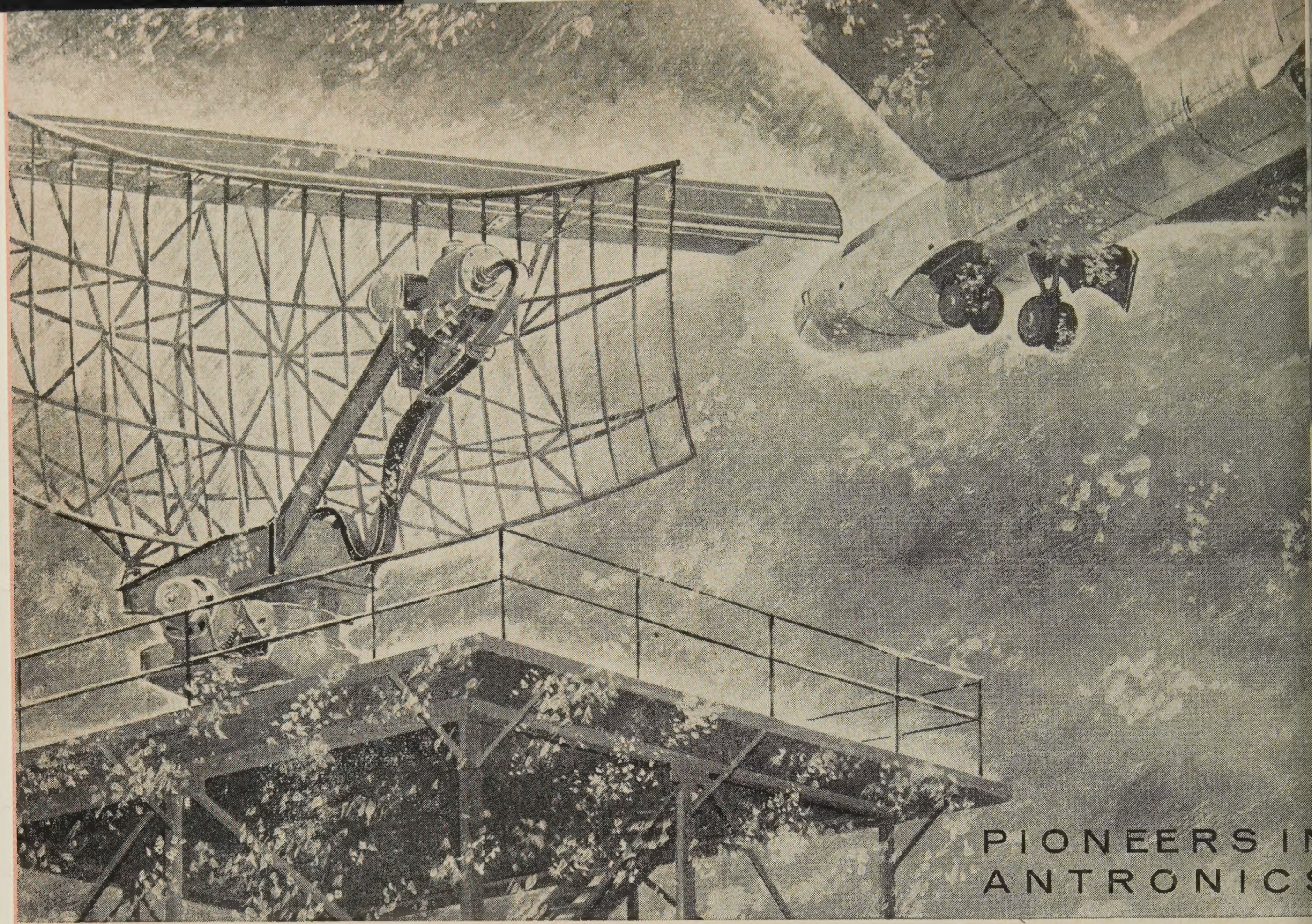

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GABRIEL'S NEWLY DEVELOPED ATCBI — a 28-foot, 32-cavity radiator, strip-fed transmission line beacon antenna — will soon be used in FAA Airport Traffic Control Systems in conjunction with ASR primary radars. When primary radar systems are supplemented by beacon equipment, air traffic control is measurably improved, identifying signals are stronger, moving and stationary targets are discriminated, and targets are not lost in scope clutter. The FAA Civil Beacon System will be effective even with the airport traffic densities anticipated for many of the larger cities.

Successful development of circular polarization and strip-fed transmission line techniques for systems such as the ASR-4 antenna and the ATCBI are bonus products of Gabriel's continuing program of advanced research in the design and performance of antenna components.

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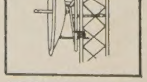
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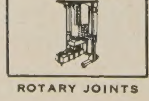
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Low Cost Significant price reductions from the level of other PM focused tubes make these units competitive with the price of solenoid, tube, and power supply.

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High Performance No electrical performance is sacrificed in attaining the advantages these long-life tubes have over solenoid types: TW-4260 delivers a minimum of 1 watt over the full 2-4 kmc octave, and the TW-4261 achieves 10 mw minimum power and 37 db minimum gain over the same range.

For more information on these or other units in Sylvania's extensive line of TWT's, contact your nearest Sylvania tube sales office or write, wire or phone Sylvania Special Tube Operations, 500 Evelyn Avenue, Mountain View, California.

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MICROVIEWS

OF THE MONTH

43 ▶ ELECTROMAGNETIC PROPERTIES OF FERRIMAGNETICS AND THEIR APPLICATIONS FROM UHF TO MILLIMETER WAVES — Part I

Benjamin Lax and Kenneth J. Button

An extensive review of the most recent advances in the understanding and the application of ferrites, garnets and antiferromagnetics is presented in three installments. Part I describes the propagation characteristics of ferrite loaded rectangular waveguide including the fundamental waveguide mode and two new classes of modes. Nonreciprocal propagation in coaxial line and the modes of the ferrite-loaded tunable cavity resonator are also discussed. Part II gives a description of spin waves and magnetostatic modes and their practical importance in high power applications, the ferromagnetic amplifier and in resonance line-broadening. Part III is devoted to a description of the operating principles and performance characteristics of new devices in three important areas. Emphasis is placed on the UHF devices, millimeter wave applications and the reciprocal phase shifter.

50 ▶ THE TRAVELING WAVE RESONATOR AND HIGH POWER MICROWAVE TESTING

Stanley J. Miller

The traveling wave resonator is a comparatively new microwave circuit which enables the component designer to test transmission type devices at power levels considerably above those usually available in the laboratory. The fundamental difference between testing with the traveling wave resonator and testing with standing wave simulation or by partially evaluating the component under test, is that the component can be tested with a traveling wave having the peak and average power to which the component under test will be subjected in actual system usage. In the first part of this paper, examination will be made of the theoretically predicted performance of the traveling wave resonator. In a second part of the paper, experimental results and a qualitative verification of the theory will be presented.

59 ▶ CALCULATION OF MICROWAVE ANTENNA RADIATION PATTERNS BY THE FOURIER INTEGRAL METHOD

L. Clayton, Jr. and J. S. Hollis

This paper discusses the well-known Fourier integral technique of calculating the radiation pattern from a set of assumed, calculated, or measured data about the antenna under design and includes a description of a Fourier integral computer.

67 ▶ DETECTION AND MEASUREMENT OF SPURIOUS SIGNALS GENERATED BY MICROWAVE OSCILLATOR TUBES

R. E. Booth and R. G. Veltrop

Two methods of detecting and measuring spurious signals generated by microwave oscillator tubes are given in this paper. The first is a point-by-point technique which employs a manually-tuned receiver to examine the output of the tube under test. The second is the search receiver technique which uses the tube under test as the swept local oscillator of a receiver.

OUR COVER

Group 46 Traveling-Wave Resonator at Lincoln Laboratory. See page 50.

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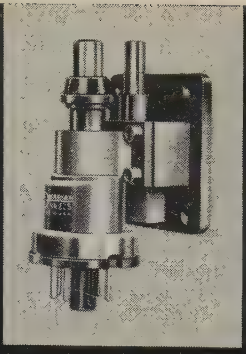

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From the editor

THE INDIVIDUAL

A friend recently pointed out to us that progress is usually achieved as the result of the efforts of individual men rather than of large groups. Where large groups have made substantial gains for society there has invariably been a single individual primarily responsible for the group action.

There is a great need to encourage people to be individuals. The herd instinct is strong in many of us, but we are each of us, because of the privacy of our innermost thoughts, first and foremost individuals.

Today there is an increasing trend towards reducing all of us to statistics. People are either in one category or another for one reason or another. We hear talk about the average man, the average family, the average community etc. Sameness and mediocrity are the order of the day.

What is even worse is the phrase we have been guilty of using — "the average engineer." A much better phrase that we would like to promote is — "the individual engineer."

There is much talk about a shortage of engineers, but a shortage that is much more serious is the shortage of individuals. This is true not only of the microwave industry but of society in general.

One of the most important things we can do to help young engineers starting out is to make them aware of their fundamental importance and tremendous potential as individual contributors.

We live in probably the best society in the history of mankind. The greatness and strength of this society is derived mainly from the respect and regard for the individual.

Our industry, which we like to think is one of the most progressive in this probably best of all societies, is also in debt to the contributions of many great individuals. Where would microwaves be today without the individual contributions of Hansen, Southworth, the Varian brothers and hundreds of others?

There is much to be said for administration and organization, but when it interferes with the ability of the individual to contribute, it is wrong and has no place in our industry.

This is not to imply that large organizations tend to stifle the expression of individual talent. The truth is that several of our best companies go to the other extreme and create an atmosphere conducive to individual performance.

Nor does it mean to imply that this situation is the fault of over-organization alone. Actually too many of us would prefer to be an average statistic.

But as one philosopher said, "Mediocrity is its own best reward."

Ted Saad

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Across the microwave spectrum, from anode toppers to timing blocks; from antennas to duplexer pins, to filament cores, to light pipes, phaser assemblies and probe insulators; from slot arrays to slip ring disks and sweep arms, to transformer locks and cores, to timers and tubes . . . Rexolite plastic dielectrics and Brand-Rex technical service have teamed to stamp "solved" on a long list of complex microwave insulation problems.

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Harold Alden Wheeler

President, Wheeler Laboratories

The IRE will celebrate its 50th anniversary in 1962. To commemorate this event, the May issue of the "Proceedings" that year will include an encyclopedia covering the past 50 years, and a symposium on the next 50 years, entitled "Communications and Electronics — 2012." It is significant that Harold Alden Wheeler has been invited as a key participant in both these activities. He will prepare the article on "Microwave Measurements" for the encyclopedia and will contribute to the symposium.

Harold Wheeler is uniquely qualified for these IRE assignments. Before World War II, he was a pioneer in the design of radio broadcast receivers for sound, FM and TV. During the war, he was a leader in IFF for radar. Subsequently, he has specialized in microwaves and antennas for communications, radar and guided missiles. He is the founder and president of Wheeler Laboratories, Inc., and a vice president and director of Hazeltine Corporation, its parent company.

A native of Minnesota, Wheeler was born in St. Paul in 1903. During his childhood, he lived in Mitchell, South Dakota, after which he moved to Washington, D.C., for high school and college. Before high school he had read every non-fiction book (except for cook books) in the Mitchell Public Library and decided to become a radio engineer. He graduated from George Washington University in 1925 with a BS degree in physics, and continued with postgraduate studies in physics at Johns Hopkins University.

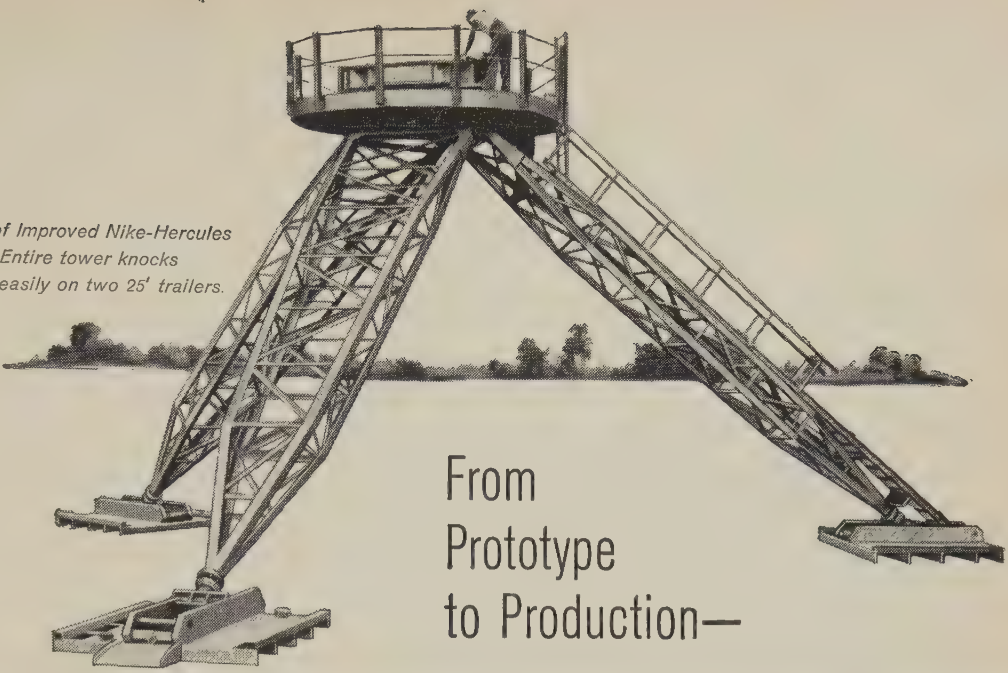
After World War I he qualified for a commercial operator's license and equipped an amateur station (3QK). However, he was more interested in testing and experimenting. During the summers of 1921-22, he was employed as a laboratory assistant at the Radio Laboratory of the Bureau of Standards, where the Naval Radio Laboratory and the Signal Corps Radio Laboratory also had their beginning after World War I. That was an unusual introduction to some of the more advanced work of those days when sound broadcasting was in its infancy and the Sun day papers had complete supplements on "How To Mak Your Radio."

During this same period, Wheeler's father was representing the Department of Agriculture on the Interdepartmental Radio Advisory Committee (IRAC), whos membership also included prominent radio experts suc as Professor Hazeltine of Stevens Tech. Through thi acquaintance, young Wheeler was introduced to Hazeltin at Hoboken in 1922. They presently discovered that the were both working on the neutralization of feedback i a triode RF amplifier, and had both arrived at the sam solution. It turned out that Hazeltine had been muc earlier with the idea, whereas Wheeler had already pu it into an operative receiver. This fortunate meeting resulted in Wheeler's affiliation with the Professor an subsequently with Hazeltine Corporation from its inception in 1924. This part-time employment enabled continuation of his college studies until 1928, followed by full time work in the Hazeltine laboratory, then located a Stevens in Hoboken.

Wheeler's principal work at the Hazeltine laboratorie from 1924 until World War II was the design of broadcast receivers with improvements for various manufacturers. This advanced into "all-wave" receivers and antennas, then FM and TV receivers. Wheeler was in charg of the company's research laboratory in Bayside unti 1939, when Hazeltine moved to its present location i Little Neck, Long Island. He was then designated vic president and chief consulting engineer.

During World War II, the principal responsibility o Hazeltine Corporation was the engineering for the Nav program of IFF (Interrogation Friend or Foe) for a kinds of radar on Naval aircraft and ships, also on a other ships of the Allies. Wheeler was one of the leader in this work, first on the Mark III system, which wen

(*Continued on page 41*)



Field Army Version of Improved Nike-Hercules Radar Tower. Entire tower knocks down and packs easily on two 25′ trailers.

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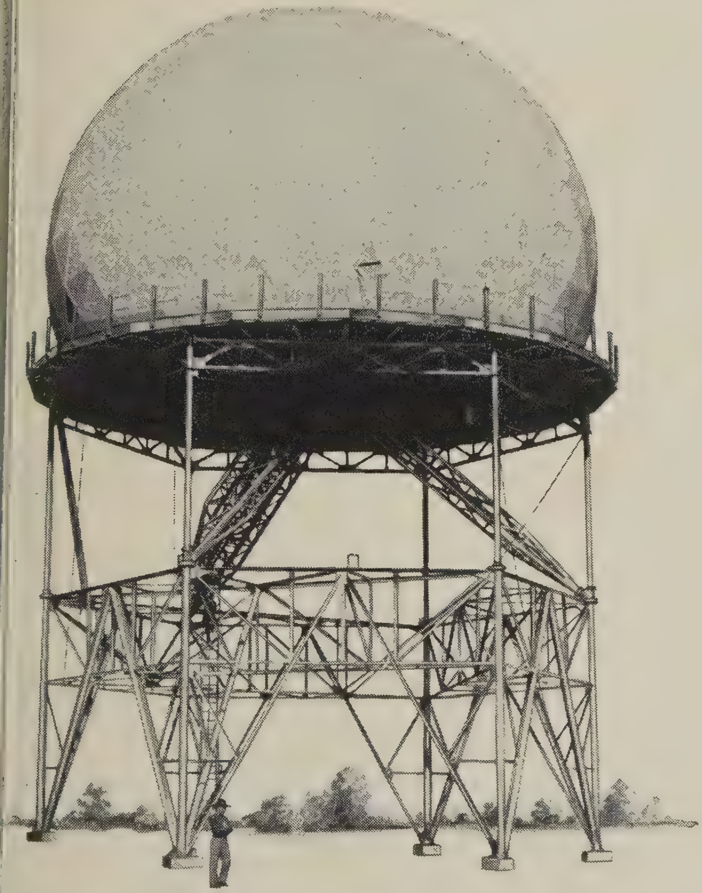

xed-Site Version of Improved Nike-Hercules Radar Tower incorporates he field army tower mounted on a 25′ height-extension and fitted with a radome.

These antenna support structures for the U.S. Army's Improved Nike-Hercules Missile System illustrate the kind of complete structural service rendered by Dresser-Ideco Company.

In designing and building both the field army and fixed site versions of this tower for Bell Telephone Laboratories, Inc. and Western Electric Company, Dresser-Ideco performed the following services:

- **Conducted design and feasibility studies**
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- **Wrote erection and maintenance manuals**
- **Manufactured the two prototype towers**
- **Erected and tested prototype of the field army tower**
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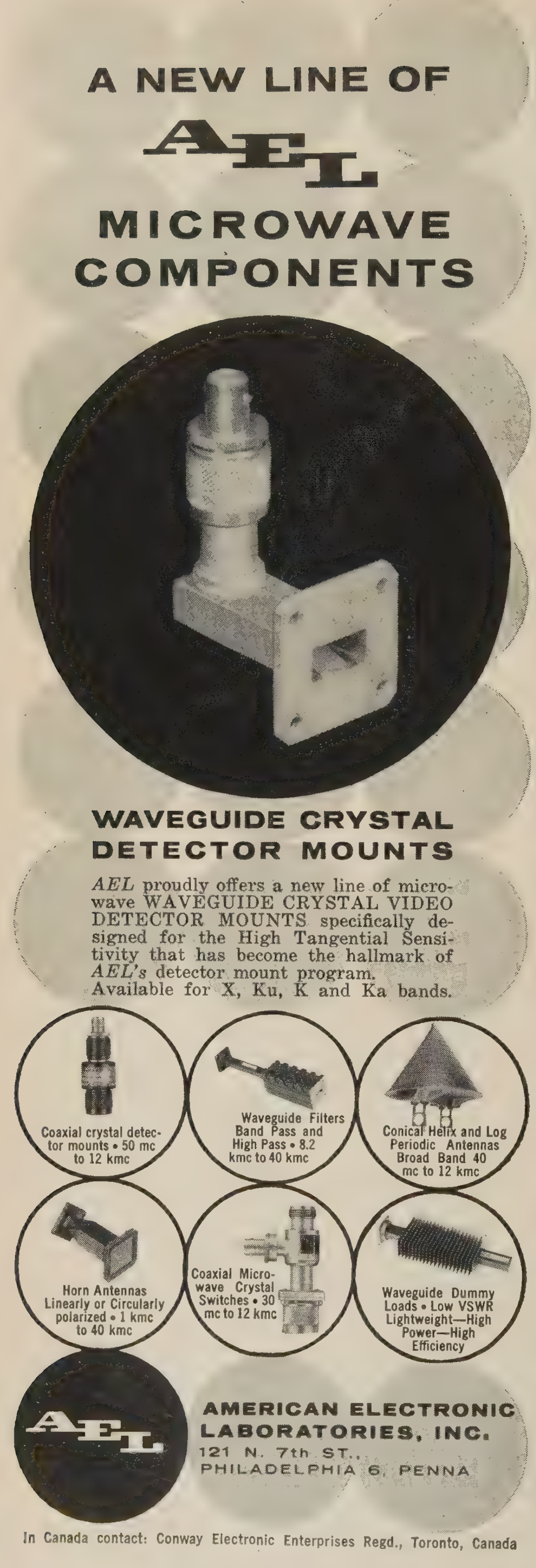

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WHEELER

(*Continued from page 10*)

immediately into service, and then on the Mark V, whi evolved into the present system. For this activity, he ceived the Navy Certificate of Commendation.

In 1946 Wheeler left Hazeltine Corporation to und take independent consulting work. In 1947 he form Wheeler Laboratories, Inc., whose function was to p vide specialized engineering services for manufacture ranging from consultation to advanced development a experimental models. This engineering group has grow to 40 engineers and an equal number of supporting p sonnel. Their facilities now include two laboratories Long Island: the Microwave Laboratory in Great Ne and the Antenna Laboratory in Smithtown. Their prin pal activity is the design of microwave circuits and ante nas for communications, radar and guided missiles.

In the meantime, Hazeltine Corporation had grown a major manufacturing organization. With about 3,5 employees in facilities at Little Neck, several other lo tions on Long Island, and at Indianapolis, its princip activity was the design, development and manufacture military electronic equipment. Last year, Hazeltine a quired Wheeler Laboratories, which is continuing i expanding operations as a subsidiary under Mr. Whee er's guidance.

Wheeler's early work was directed mainly to the d velopment of improvements in broadcast receivers. Du ing the Christmas holidays of 1925, he completed a supe heterodyne receiver that was the first to utilize diod linear detection and automatic volume control. By 193 as a result of his practical designs, this feature had bee adopted for universal use in broadcast receivers.

Much of his activity was directed to improving th methods of measuring and rating radio apparatus. Fo use in standard signal generators, he developed the "piston attenuator" in a hollow pipe of shielding material This was its first use as a "primary standard" in whic the attenuation was computed from mechanical dimensions. In 1929-35 he put into service several types, utilizing the modes now designated as circular TM-01 an TE-11, and rectangular TE-10, in "waveguide beyon cutoff." The latter may have been the first use of thi mode which is now the most common.

Wheeler's specialization in antennas and transmissio lines dates back to 1934, when he undertook the desig of "all-wave" antennas. This required wideband transformers and impedance matching between a dipole antenna and a line over the range of 6-18 mc. During th war he again became active in antennas and lines but a the higher frequencies in the range of 150-1200 mc.

In working with transmission lines, he made early us of some of the non-circular cross-sections that are no well known. For example, in 1942, he used round conductors between parallel planes in the construction of line stretcher of the "trombone" type. In 1943 he use strip lines between dielectric slabs and parallel planes fo the same purpose. From his designs, the Hazeltine laboratory in 1946 was equipped with slotted lines made o round conductors between parallel planes, the type tha has since come into common use. Those lines were fou meters long so they could be used down to 40 mc, including all FM and TV channels.

(*Continued on page 15*)

x Styroflex® Coaxial Cables on One Tower

...feed antennas for WIIC (TV) and WWSW-FM in Pittsburgh!

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nd for radio station WWSW-FM.

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1 KW auxiliary transmitter and terminate in sep-
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primary antenna feed for WWSW-FM, with a
ble acting as a standby line for this station.

Long operating life and stable electrical properties in a wide variety of climatic conditions make Styroflex® cable ideal for many kinds of applications. Manufactured in 1000-foot lengths, Styroflex® cable eliminates the need for 20-foot interval connectors that can cause gas leakage problems in rigid lines. The longer cable lengths also simplify installation of cable runs.

The performance record of Styroflex® cable has earned for it an outstanding reputation in telemetry, guided missile and mass communication applications. If you have need for a superior high frequency cable with proven properties, we suggest you consider Styroflex®.

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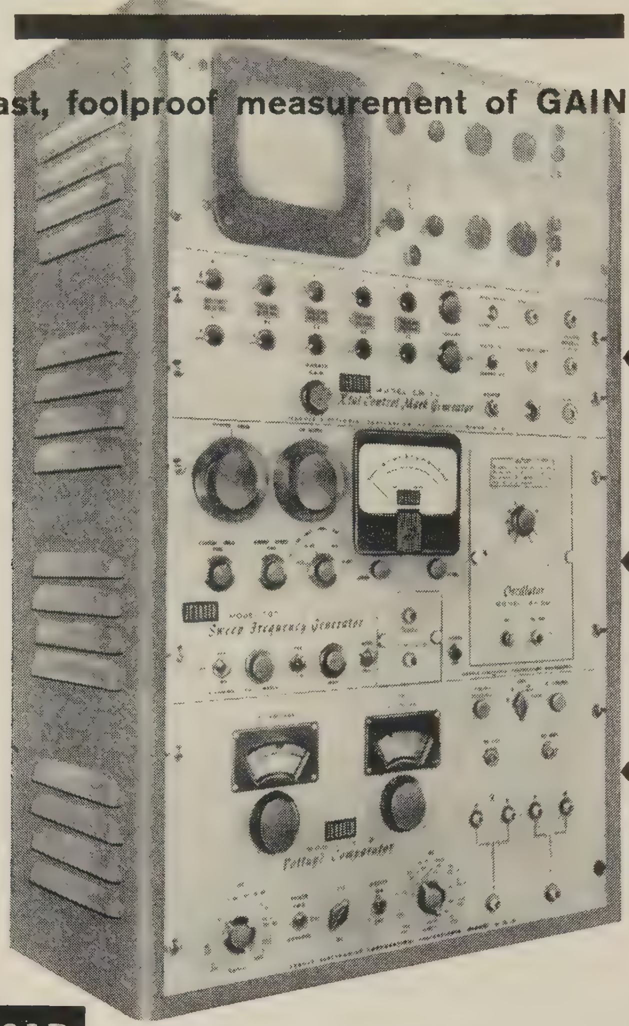
Circle Reader Service Card 9

BEST TEST SET YET!

For fast, foolproof measurement of GAIN, LOSS, VSWR, Q, X_L, X_C, Z



Crystal Controlled Marker Generator

Model CM-10—A 10-crystal unit producing any selected fundamental and/or harmonic frequencies. Each oscillator has its own independent amplitude control. Features built-in scope pre-amplifier and VSWR filter.

Precision Sweep Generator

Model 707—The heart of the test set. Features an extremely flat RF output (±5/100 db) and variable rate, all electronic sweep with plug-in oscillators available covering 2 to 265 mcs. Provisioned for use with an X-Y plotter.

Accurate Voltage Comparator

Model VC-12 — The unit that makes Measurement By Comparison possible. A 3-section instrument that contains regulated DC and RF voltage supplies and a wide band coaxial comparator for the simultaneous visual presentation of reference standards against which the test information is compared.

Model 1707 Price **$1,570.00**
(Oscilloscope, rack, or recorder not included)

JERROLD MODEL 1707

Complete RF TEST SET employs the Measurement By Comparison technique

Interested in more than one frequency . . . an entire band, octave, or spectrum? Now it's no longer necessary to employ the slow, tedious, point-by-point method of measurement when working with a spectrum of frequencies. Jerrold's new 1707* test set will do the same measurement job *Faster*, more accurately, and with fool-proof results. Featuring the **Measurement By Comparison** technique, the model 1707 provides a continuous visual presentation and self calibration against precision standard attenuators (and/or accurate DC and RF voltage sources referenced against a standard cell). So, whatever your laboratory, production, or field needs—Jerrold's sweep frequency **MBC** method will serve them better.

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*Similar test sets available for other ranges

ld A. Wheeler, seated center, president of Wheeler Laboratories, Inc., and vice president and director of Hazeltine Corp., discusses a problem with his staff.

IEELER

(Continued from page 12)

Vhen confronted with problems of transmission lines,
eeler recognized in circle diagrams a most valuable
in analysis and design, especially in the hemisphere
rt or reflection chart of P. S. Carter and P. H. Smith
th published in 1939). In 1942, he obtained trans-
ent graph paper printed with the Carter chart, and
was used thereafter for the presentation of data in
of the laboratory work and reports of the antenna
up at Hazeltine. In Wheeler Laboratories more con-
ient forms were adopted and put into use for all
nputations and measurements in transmission lines
hollow waveguides. Currently Wheeler is serving
hairman of the EIA committee for standardizing the
m of the reflection chart.

n the field of guided microwaves, Wheeler has partici-
ed in the design of numerous components and circuits
vell as the development of advanced theories and tech-
ues. The backward directional coupler between
rter-wave parallel lines was one of his wartime de-
opments. He has put into use various kinds of high-
ver rotary joints, including the step twist (for 40
cent bandwidth) and a special form of waveguide-to-
xial-line joint (for 20 per cent bandwidth). He has
igned various kinds of filter circuits in waveguide.

n Wheeler Laboratories, his specialization in anten-
has continued in great variety. The most intensive
rt has been devoted to tracking radar as utilized in
ded missile systems. For example, Wheeler and his
ciates, as subcontractors to Bell Telephone Labora-
es, designed the precision tracking-radar antennas used in the Nike Hercules anti-aircraft missile system now in service, in the Titan ICBM presently going into service, and in the Nike Zeus anti-missile system now under development. As subcontractor to Sperry, they are designing an advanced form of tracking-radar antenna for the Terrier-Titan anti-aircraft missile system. In the commercial field, Wheeler's group is responsible for designing the mobile communication antennas being manufactured by Communication Products Co., Marlboro, N. J.

During the past few years, Wheeler has been active as an antenna consultant in the field of Navy VLF communications, especially for reaching submarines while submerged. Working with Developmental Engineering Corp., he participated in the design of the tremendous transmitting antenna now under construction at Cutler, Maine. It will be the first to radiate one megawatt of CW power at frequencies down to 14 kc. Now Wheeler is active in studies for future improvement of radio communication to submarines.

The skin effect has been of continuing interest to him from the early days of designing RF coils and shields. Working from the concepts of W. W. Hansen just before the war, Wheeler has developed and published useful theorems and charts for various applications of the skin effect. These cover the entire frequency range from microwaves down to sub-audio, and all kinds of conductors from copper to sea water, land and ionosphere. Special problems have involved conductors of polygon cross-section, unusual waveguides, powdered iron, underwater and underground antennas, and guided-wave propagation under the ionosphere.

(Continued on page 17)

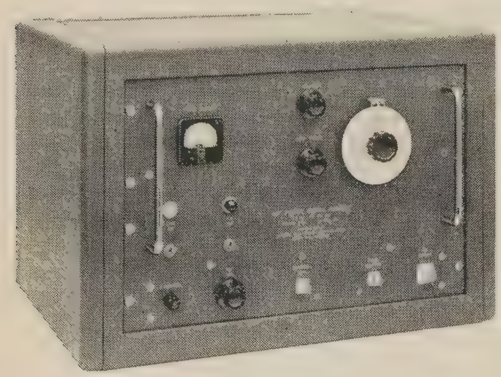
Delivery from stock

NEW VHF-UHF POWER SOURCES

FULL-RANGE STABILITY

50 WATTS OUTPUT

25 to 1,000 MC!



Available in four off-the-shelf models covering the frequenc range 25 to 1,000 MC, the new Sierra Electronic Corporatio Model 215 Series VHF-UHF Power Sources provide extremel stable output to 50 watts. This unusual stability insures hig repeatability for both routine check-out and precision laborator work.

The instruments are continuously tunable over their respective ranges, offer high frequency stability and dependable operational stability under line voltage variation. Output power is adjustabl 20% to 100% of rating. A plate current meter is provided fo coupling adjustment, and a front-panel jack permits frequency monitoring with an external counter.

Sierra 215 Series Power Sources are easy to operate, completely self-contained and housed in sturdy bench cabinets. Rack mountable models also are available. They are ideal for accurate calibration of bi-directional power monitors and termination wattmeters, as well as for work in antenna design or other applications involving high attenuation of input signals.

SPECIFICATIONS

Frequency range:	Model 215A-50, 25 to 50 MC Model 215A-150, 50 to 150 MC Model 215A-470, 150 to 470 MC Model 215A-1,000, 470 to 1,000
Power output:	50 watts ± 1.5 db, into 50-ohm load, adjustable 20% to 100% of full power
Output stability:	± 5% after warmup
Frequency stability:	± 0.05% after warmup
Dial accuracy:	± 2% Models 215A-50/150 ± 3% Models 215A-470/1,000
Resetability:	0.1%
Modulation:	External AM
Price:	$3,300.00.

Data subject to change without notice. Price f.o.b. factory

sierra

For complete details, see your Sierra Representative or write direct.

SIERRA ELECTRONIC CORPORATION
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Export: Frazar & Hansen, Ltd., San Francisco, Los Angeles

Circle Reader Service Card 11

(Continued from page 15)

the various theoretical topics in which Wheeler has an active interest, he has been most attracted to which are expressed in terms of the complex vari- He was introduced to this subject in various prob- by Professor Hazeltine and has found it indispen- in many applications. This is the common language C circuits, frequency-selective networks, transient omena, beam antennas and two-dimensional fields. as taken a particular interest in the analogy between ems in any two of these categories which happen are the same mathematical form. An example is the gy between the potential of a grid of wires and the be structure of a beam-antenna radiation pattern. it becomes possible to translate from experience in nvironment to new ideas in another environment.

e accomplishment from which Wheeler derives the satisfaction is the organization of the staff of Wheel- boratories into an effective engineering group. This ed on the discipline of tackling any problem objec- and verifying every step toward the end result. ess is described in terms of the ideas, not just the rical values. Among other things, this requires that engineer continually develop his powers of expres- y preparing reports in his own words, with the e and criticism of his associates. The most difficult ems are sometimes those of management on admin- on, and these also are tackled by group action with ngineering approach. The result is quite a powerful with much credit due to all members of the group.

heeler has published many scientific papers over the past 35 years, including 38 in IRE "Proceedings" and "Transactions," and 19 in a post-war series entitled "Wheeler Monographs." He has been granted about 180 U. S. patents and many foreign patents.

He is a fellow of IRE, AIEE and Radio Club of America; an Associate Member of IEE (Great Britain); and a member of Sigma Xi and Tau Beta Pi honorary scientific fraternities. Among his honors and awards, the most treasured is the Morris Liebmann Memorial Prize from IRE in 1940, for contributions to the theory of wideband amplifiers used in television.

Most of Wheeler's hobbies have been related to science and engineering. In his school days, he spent much of his spare time with woodworking and mechanical construction sets, model airplanes, electrical models and experiments, and radio. In his first summer in Washington, he read all the public library books on electricity, aviation, model airplanes and wireless. In addition, he became proficient as a pianist, concentrating on the classics. He also has enjoyed dancing since his high school days.

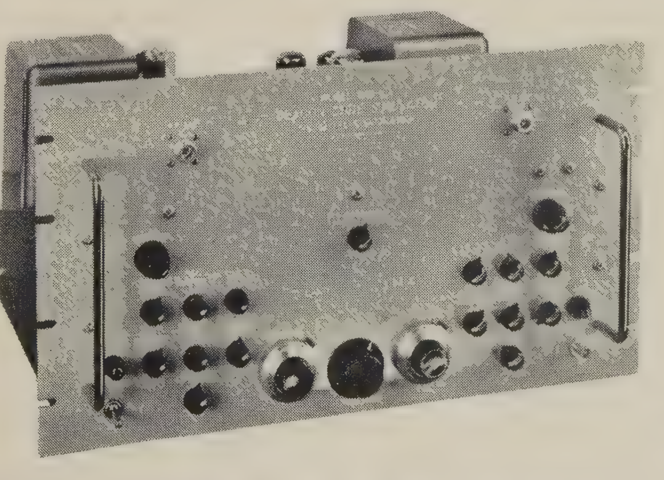
Mrs. Wheeler, the former Ruth Gregory, was a student in one of his college classes in Washington while her father, Rear Admiral L. E. Gregory, was chief of the Navy's Bureau of Yards and Docks. The couple has lived in Great Neck on Long Island's North Shore for the past 30 years. They have three children, two of whom are married and have provided seven grandchildren.

The Wheelers spend their vacations traveling, often to the West Coast where they have many friends and relatives, including some of their grandchildren. Last April they enjoyed three weeks in the Hawaiian Islands, where they explored the fiftieth state, and Mr. Wheeler presented a paper to the Honolulu Section of the IRE.

BEACON CODE SIMULATOR | TESTS BEACON INPUT and PULSE DECODING CIRCUITS

or: *PREFLIGHT • PRODUCTION LINE • QUALITY CONTROL • LABORATORY

EATURES:
- ll "C" and "S" band overage
- ouble or single rf and ideo pulses
- 0 db rf attenuation range
- ll adjustment of all ulse parameters
- re-set pulse adjustment or each rf band
- ulse and cw operation
- perates with 60-400 cps nput power



*Used By Bendix Radio, Towson, Maryland on Project Mercury

MODEL PSG-10A
in a single unit provides a double-pulsed microwave signal source designed to check performance of pulse-coded "C" and "S" band beacons.

Frequency: 2.7-2.9 Kmc
5.1-5.9 Kmc
Power Output: 100 milliwatts (S-band)
80 milliwatts (C-band)
Attenuator Range: 40 db
Pulse Width One: 0.3 to 10 μsec
Pulse Width Two: 0.3 to 10 μsec
PRF: 10-2000 pps
Pulse spacing: 0-100 μsec
Rise time: 0.1 μsec
Fall time: 0.2 μsec

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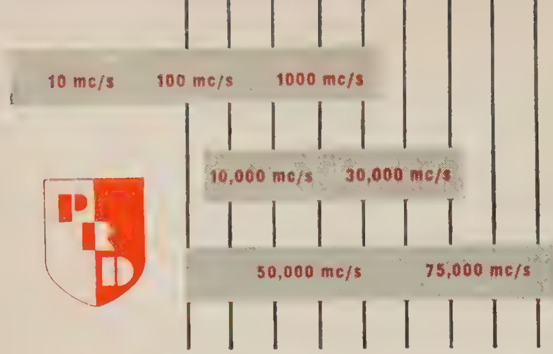


for every band...t most complete line of precisi microwave test instrumen

Band	**S**		**G**		**C**		**H**		**X**
WAVEGUIDE DIMENSIONS (INCHES)	3x1½		2x1		1½x¾		1¼x⅝		1x
FREQUENCY RANGE (kmc/sec)	2.60-3.95		3.95-5.85		5.85-8.20		7.05-10.0		8.20-
ATTENUATORS									
Broadband			G101	$490	C101	$ 340	H101	$ 340	X101
Variable					1156	$ 75			154-A
Precision gauge	175-B†	$375	170-B	$325	178-B	$ 300	185-B	$ 275	195-B
Precision dial	174-B†	$290	169-B	$235	177-B	$ 230	184-B	$ 200	196-C
Fixed waveguide	137	$ 75	120	$ 65	119†	$ 65	118	$ 60	140
Level set	171-B 171-A	$115 $105	162-B 162-A	$105 $ 95	156-B 156-A	$ 100 $ 90	160-B 160-A	$ 90 $ 80	159-B 159-A
TERMINATIONS									
Fixed	129-A	$ 45	115-A	$ 35	121-A	$ 30	114-A	$ 25	116-A
Sliding	1129	$100	1115	$ 75	1121	$ 70	1114	$ 60	1116
FERRITE ISOLATORS			1205	$270	1204	$ 245	1206	$ 230	1203
SLIDING SHORTS	315	$150	316	$140	317	$ 130	318	$ 120	319
PRECISION MISMATCHES	1404	$300	1401	$225	1403	$ 175	1400	$ 150	1402
SLOTTED SECTIONS	209-A	$590	201-A	$390	204-B	$ 340	202-B	$ 340	203-D
SLOTTED LINES*									X231
TUNERS: Slide screw	309-A	$150	300-A	$140	305-A	$ 135	302-B	$ 130	303-A
E-H									
ADAPTER: Waveguide to coaxial	365-A	$ 50	357	$ 40	356-A	$ 35	355-A	$ 30	354-B
DIRECTIONAL COUPLERS									
(40 db)	409	$350	410	$240	411	$ 140	412	$ 120	408
(20 db)			400	$250	404	$ 200	401	$ 175	402
BENDS AND TEES									
E Bend			450	$ 70	454	$ 50	458	$ 35	462
E Tee			452	$ 85	456	$ 65	460	$ 50	464
H Bend			451	$ 70	455	$ 50	459	$ 35	463
H Tee			453	$ 85	457	$ 65	461	$ 50	465
E-H Tee			478	$100	479	$ 85	480	$ 70	481
CRYSTAL MOUNTS									
Fixed									601
Tunable									
BOLOMETER MOUNTS									
Tunable									
Fixed									
THERMISTOR MOUNTS	644	$125	645	$ 95	646	$ 90	647	$ 90	643-A
WAVEGUIDE STANDS	370	$7.50							
BROADBAND PROBES	250-A	$145							
WAVEGUIDE ADAPTERS									
FREQUENCY METERS									
Broadband direct reading			532	$380	533	$ 295	534	$ 290	535
Precision direct reading					555† 556†	$1500 $1500	557† 558†	$1500 $1500	559† 565†
Direct reading			590-A†	$350	588-A†	$ 250	586†	$ 150	585†
FLANGE BOLT ASSEMBLY	369-A	$4/dz.	369-B	$4/dz.	369-B	$4/dz.	369-C	$4/dz.	369-D
CALORIMETER									
TUBE MOUNTS			704†	$200			702†	$ 200	703†

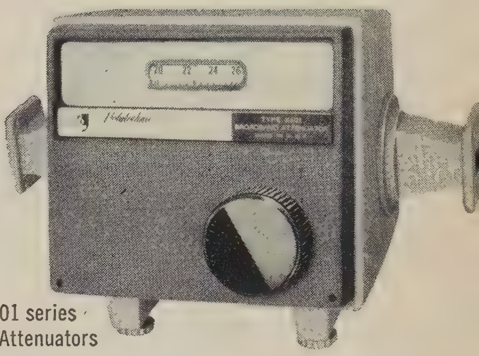
ADDITIONAL MICROWAVE INSTRUMENTATION:

STANDING WAVE AMPLIFIER	277-B	$ 195
KLYSTRON POWER SUPPLY	809	$ 350
UNIVERSAL KLYSTRON POWER SUPPLY	812	$1495
UNIVERSAL BWO/TWT POWER SUPPLY	813	$2900
UNIVERSAL POWER BRIDGE	650-B	$ 320
VHF-UHF NOISE GENERATOR	904	$ 490

*For PRD 230 UNIVERSAL PROBE CARRIAGE
†not full band coverage

NEW PRD 230
Universal Probe Carriage

NEW PRD 277-B Standing Wave Amplifier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Broadband Attenuators

	K		A		Q	
	.500x.250		.360x.220		.148x.074	
	18.0-26.5		26.5-40.0		50.0-75.0	
$ 265	K101	$ 425	A101	$ 425	193	$ 370
$ 275	153-B	$ 325	192-A	$ 350		
$ 200						
$ 60						
$ 85	155	$ 110	157	$ 125		
$ 75						
$ 25	132-A	$ 30	133-A	$ 35	1103	$ 65
$ 55	1132	$ 65	1133	$ 75		
$ 220	1209	$ 270				
$ 125	312	$ 170	322	$ 140	326	$ 150
$ 150	1406	$ 330	1407	$ 340		
$ 425	211-B	$ 425	212-B	425	216-A	$1250
$ 110	K231	$ 235	A231	$ 235		
$ 130						
$ 135	313-A	$ 155	312-A	$ 170	323	$ 280
$ 100						
$ 200						
$ 35	470	$ 40	474	$ 45	490	$ 50
$ 45	472	$ 50	476	$ 60	488	$ 60
$ 35	471	$ 40	475	$ 45	486	$ 50
$ 40	473	$ 50	477	$ 60	487	$ 60
$ 55	483	$ 70	484	$ 85	489	$ 80
$ 140	6605	$ 140	6606	$ 140		
$ 170	621-A	$ 185				
$ 170	621-A	$ 185			632	$ 125
$ 140	620	$ 115	618	$ 115		
$ 105	607	$ 150				
	253	$135				
	3360	$ 38	3362	$ 38		
	3361	$ 38	3363	$ 38		
$ 285	537	$ 290	538	$ 300		
$1500	568†	$1500	570†	$1500		
$1500	569†	$1500	571†	$1500		
$4/dz.						
			666	$975		

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DATA AND PRICES ARE SUBJECT TO CHANGE WITHOUT NOTICE.

COAXIAL TEST EQUIPMENT

INSTRUMENT	MODEL NUMBER	FREQUENCY kmc/sec	PRICE
Adapters "N" to 7/8 inch	389 to 392	0 - 5.0	$ 53
"C" to 7/8 inch	3350 to 3353	0 - 5.0	$ 55
VHF-UHF Detector	641-A	0.01 -10.0	$ 25
Bolometers	631 Series	0.5 -10.0	$ 25
Ferrite Isolator	1211	2.0 - 4.0	$ 295
Slotted Sections	200-C	1.0 - 5.0	$ 475
	215-A	1.0 - 4.0	$ 475
	205-A	4.0 -10.0	$ 475
Slotted Line*	N231	4.0 -10.0	$ 195
Standing Wave Detector	219	0.1 - 1.0	$ 525
Tuners: E-H	327	0.95 - 5.0	$ 125
Double Stub	306-A	2.0 -10.0	$ 90
E-H	328	2.7 -10.0	$ 125
Bolometer and Crystal Mounts	612 Series	1.0 -10.0	$ 145
	613	1.0 -12.0	$ 50
	622	1.0 -12.0	$ 55
Terminations	139	0 - 1.0	$ 35
	145-A	0 - 4.0	$ 95
	1107	2.0 -10.0	$ 53
Broadband Thermistor and Bolometer Mounts	627-A	0.5 -10.0	$ 95
	628-A	0.5 -10.0	$ 95
Fixed Attenuators	130	2.0 -10.0	$ 40
	136	1.0 - 4.0	$ 120
	1100	0 - 4.0	$ 55
Variable Cutoff Attenuators	180-A	8.2 -10.0	$ 200
	181	1.0 - 4.0	$ 125
	198	1.0 - 4.0	$ 150
Oscillators	701	2.4 - 3.6	$ 300
	707	0.95 - 2.3	$1500
	706	3.6 - 7.3	$ 950
	705	7.0 -11.0	$ 950
Frequency Meters	500	0.042-10.0	$3500
	504	0.1 -10 0	$ 695
	560	2.4 - 3.4	$1300
	560-S1	2.7 - 3.7	$1300
	578	0.925- 1.65	$1500
	579	1.60 - 2.60	$1500
	583-D	2.7 - 3.7	$ 650
	587-A	0.250- 1.0	$ 275

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Circle Reader Service Card 13

More Like a Doctor?

RESPONSIBILITY

MARSHALL C. PEASE, ASSOCIATE EDITOR, *the microwave journal*

Where are the limits of an engineer's responsibility?

To what extent does he share responsibility with the customer — who is, after all, paying the bills — to decide what is wanted, and even how it is to be achieved? Particularly if the customer knows only what he wants, and does not know with precision either the probability of attaining it or the probable penalty that it may involve?

If, as sometimes seems to be the case, the modern American car is too highly gadgeteered with its multiple carburetion, anticipatory throttle, automatic venticular devibrator, "et al", so that they become life incomes for the garage mechanic, is this the fault of the engineer who designed this Goldbergian paradise? Or should we blame the advertising genius who has made such troubles the mark of distinction? Or management people, clutching their aspirin bottles while trying to think how to outdo themselves next year? Or we, the people, who went overboard, willingly if with assistance, on the subject of luxury, glamor, or whatall, not reckoning the cost in terms of lost reliability?

Who should accept the blame?

If it is somebody other than the engineers, then that is their problem. But if all, or some part of it, belongs with the engineers, then it is ours.

For the same problem exists in microwave engineering. And here, in our own field, it is equally unresolved. And no less important.

Where does the responsibility lie?

To bring the matter home, most of us have been faced with requests for bids on jobs where performance could not, factually, be guaranteed. The most extreme example, probably, is a CPFF bid on a development job that involves a good bit of "blue sky" thinking and hope, but which has, as its goal, a device whose characteristics are reasonably well specified. If the bidder knows the initiator of the bid request, he may be quite confident that the purpose is simply to set up a goal to guide the contractor's thinking and to define the project. And this is a reasonable thing to do.

But, in making such a bid, we know that there will be other people involved besides the initiator. If it is a long or large contract, there will be many other people. And, quite possibly, the initiator may cease to have anything to do with the job before it is finished. Besides, even if he is still watching over it, his viewpoint may, quite unconsciously, drift with time.

Hence, to accept the specification of the end product without comment on the basis that you know what is in the initiator's mind, can easily lead to all sorts of troubles.

So, you would like to spell out, in your bid, exactly what your understanding is. You would like to put down all the "if's" and "maybe's". You want to go on reco with all the doubts and reservations that are implied the fact that the job requires something more than t known state of the art. It is not that you do not want do the job. You may even believe that there are not lik to be any major difficulties. You may believe you ha good reason to be confident that, even if you do n meet the exact specifications as written, you will still e up with a device that will meet the needs of the applic tion just beautifully. But you do want, as a matter mutual protection, to record as precisely and explicitly possible just what is your present understanding. Y want to make sure that, now and in the future, ever body knows what you think the prospects are.

Only there is a problem. Its name is "responsiveness Any exception to the specification as written automatica ly opens the way to your bid being thrown out as "no responsive". Any explicit expression of doubt of you ability to meet the specification in all its minute detai carries this danger with it.

The fact that the initiator is an intelligent chap and good engineer is no real help. With a large bid partic larly, there will be many other people involved in th decision to award. And even the initiator is going to hav to answer the lawyer's question,"Is it responsive, yes o no?"

So what do you do? The temptation is strong to rel on the fact that it is CPFF. Even if the worst happens the results will at least not show on the balance-shee Besides, you think you are going to succeed, don't you So you are not lying if you say so. And why advertis worries about vague possibilities that may never happe anyway? Besides, if you finally give the customer wha he needs, you will be "post facto" proven right. And i you don't, why then you will still be tagged with failur no matter what paragraphs you can point to in your bid So, by trying to tell everything, you risk losing the con tract for non-responsiveness, and stand to gain nothin but a feeling of righteousness.

Such rationalizations, in different forms appropriate to different circumstances, are being forced on large area of engineering today. The field of microwave engineering, while not unique in this regard, is one of those areas

It is being forced, not by individuals or by design, but by the logic of our way of doing business. The key decisions are being made by people who do not understand the field of engineering that is involved, and often do not understand engineering at all. They may not even know what is the gadget that all the talking is about. They have no basis on which to evaluate a "maybe". They must, out

(Continued on page 24)

OW! WESTINGHOUSE IN FULL RODUCTION ON FAMILY OF UNABLE X-BAND MAGNETRONS

inghouse announces a family of
ble X-Band Magnetrons available
for airborne radar service—and
production facilities to meet your
irements at all times. These high-
rmance magnetrons feature im-
ed stability, minimum frequency
, excellent spectrums, high effi-
cy and low voltage operation. The
family not only features Type WL-
, but also includes Types 7110,
, 7112 and 6865A. Some of their
cal performance characteristics are
llows:

- **Frequency range: 8500 to 9600mc**
- **Peak power output: 220 Kilowatts**
- **Pulse widths: up to 2.8 microseconds**
- **Heater voltage: 13.75 volts**
- **Frequency range excursion: 7 seconds at 1500 rpm shaft speed**

For full information, contact your nearest Westinghouse industrial tube representative, or write: Westinghouse Electric Corporation, Electronic Tube Division, Elmira, N.Y.

YOU CAN BE SURE...IF IT'S Westinghouse

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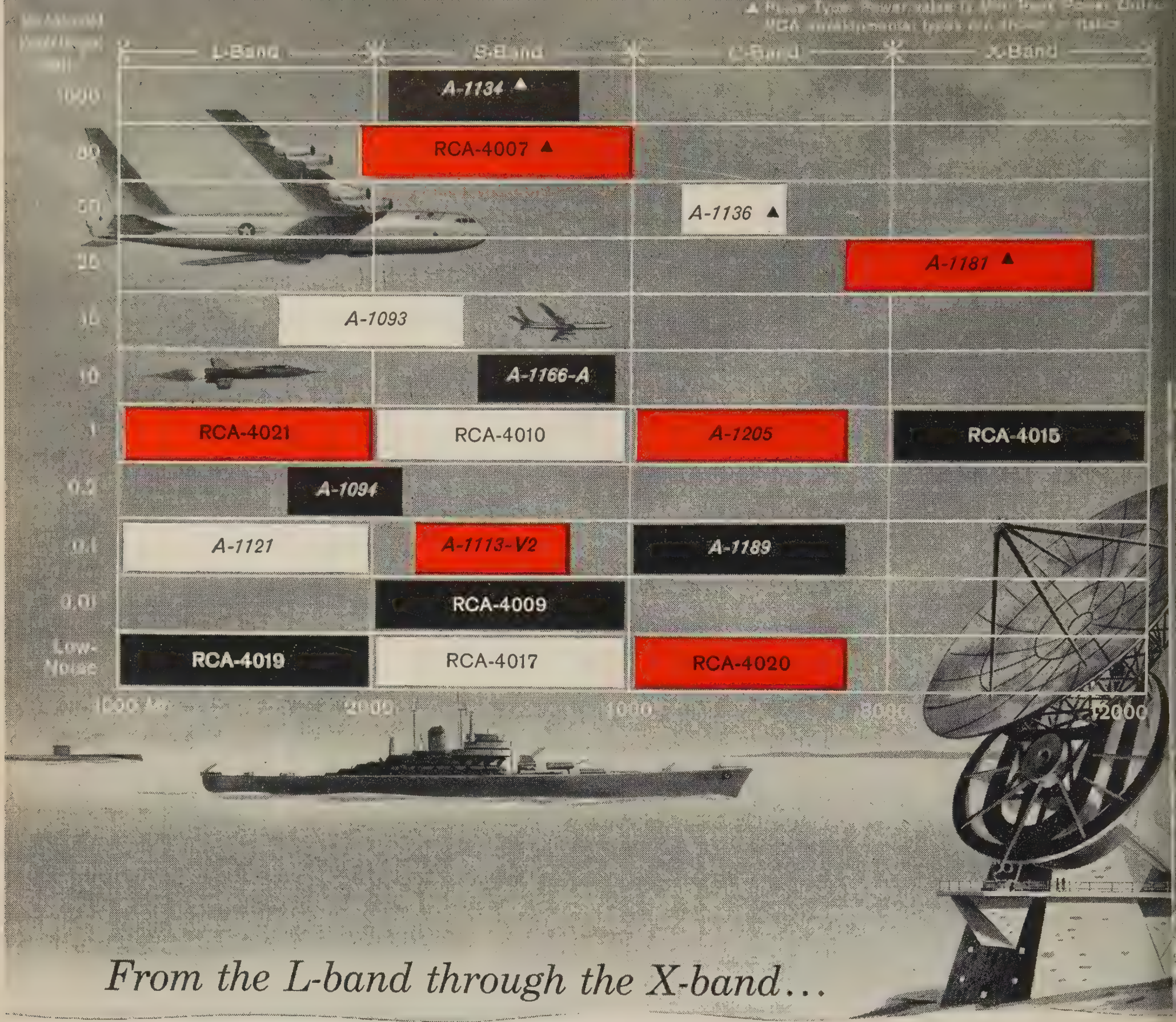

From the L-band through the X-band…

There's a reliable RCA Traveling-Wave Tube for your needs

The chart above shows the wide range of RCA traveling-wave tubes available for your designs. New types and improved versions are constantly being added to the list. Each of them is designed for long life and reliable performance. In fact, *RCA gives you a 1,000-hour warranty on all commercial TWT types.*

Under actual field conditions, it is often possible to obtain unusually long and reliable operation from RCA TWTs. For example, a recent letter from Jacques Baerlocher Corporation in Zurich reported: "The RCA-6861 installed in the ra equipment at Zurich Airport just failed a 19,200 hours of service. It is interesting to that the tube kept its good properties until the hours." Performance records such as this are result of advanced design plus the painstaking RCA puts into the manufacture of TWTs.

For complete information on RCA Traveling-W Tubes and how you can obtain "customized" t to meet your specific requirements, get in to with the RCA Field Office nearest you.

RADIO CORPORATION OF AMERICA **Electron Tube Division** **Harrison,**

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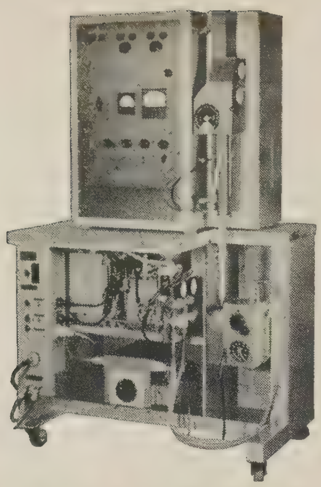

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Measures dielectric constant and loss over a wide temperature range at 1, 3, and 8.5 kmc.

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For brochure giving details and specifications, write:

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Dept. 203 — Red Wing, Minnesota

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PEASE

(Continued from page 20)

of sheer lack of pertinent understanding, read a "may as either a "yes" or, more likely, "no".

What alternative there may be to this situation is clear. It would be entirely unrealistic to advocate t engineers should make all these decisions. An engin is, by definition, a specialist, trained within a cert area of knowledge. The big decisions have consequen and implications that range far outside any area of s cialization. They require an extensive, rather than int sive, viewpoint. They should be made by a man who trained to consider all aspects, even if this implies a l than desirable knowledge of any single aspect. They quire what can only be called the executive mind.

It may be doubted, therefore, if there is any practi way to avoid the situation. It will always be necessary weigh carefully whether the customer should be told the "ifs" and "and's".

But to say that the situation is inevitable does not n gate the fact that it poses an urgent moral and ethi problem. In fact, it is just the existence and proba continuance of the situation that makes the proble urgent.

What is the ethical position of the engineer?

Is it similar to that of the lawyer? A lawyer is expect — and even required — to present his client's case in t most convincing manner possible. He may, quite proper plead a case that he has privately advised his client drop. If so, he is expected to plead it with all the convi tion he can muster. He is not expected, or even permitte to express to the opposition or to the court that sits judgment, his doubts and reservations.

There are, of course, limits. A lawyer may not suppre what he knows to be facts, even though they may be detr mental to his client's interests. Likewise, no one sugges that it is ethical, or wise, for an engineer to be party to bid that says he will do something that he knows to impossible.

There are limits, but within the limits, there is lo of room.

Is this the position of the engineer when he deals wit a possible customer of his employer? Is it his job and dut to present to the customer the strongest possible cas consistent with what is factually known, for the view point of his employer?

This is one possible answer. It is a logically consisten one, and leads to an ethical position which is not incon sistent with the dignity of a profession. It depends on th assumption that the other side, whether customer or com petition, will also have competent engineers who wil present the other viewpoint.

The alternative position is that of the doctor. A docto is "hired" to deal with a problem. He is expected to dea with it strictly on the basis of his professional knowledg and judgment, without any regard at all for what hi employer may wish.

True, the doctor may not always tell all that he know or suspects. He, too, may withhold his doubts. But th ethically valid reason for suppressing such thoughts i not that it would make his employer unhappy, but tha it might create additional medical problems.

(Continued on page 27)

DEAD END for high power problems

SPERRY E42C1 RADAR SYSTEM WATER LOAD

The problems of handling high peak and average powers in ground based radar systems are ended completely by the new Sperry Water Load. Small and rugged, where previous units have been both large and delicate, this termination can handle extremes of power easily, and with relatively low water flow. Most other liquid coolants may also be used.

The Water Load is one integral unit with standard flanges, and input and output water ports with standard pipe fittings. The unit may be easily adapted to existing systems, and can replace antennas of every type for test and other purposes.

Used with thermocouples to measure incoming vs. outgoing water temperatures—plus a flow meter—the Water Load becomes a calorimeter to compute average system power.

Many other high power lab, test and research uses will suggest themselves. Address inquiries to Clearwater, outlining your projected application. *Sample quantities available for evaluation.* Please write us stating your requirements and frequency band.

SPERRY 50 YEARS 1910 1960

Typical Specifications:

Model	Peak Power	Average Power	Height	Length	Weight
E42CI (illustrated)	3.0 mw	4.5 kw	3⅝″	6¾″	3 lbs.

ERRY MICROWAVE ELECTRONICS COMPANY, *CLEARWATER, FLORIDA · DIVISION OF SPERRY RAND CORPORATION*

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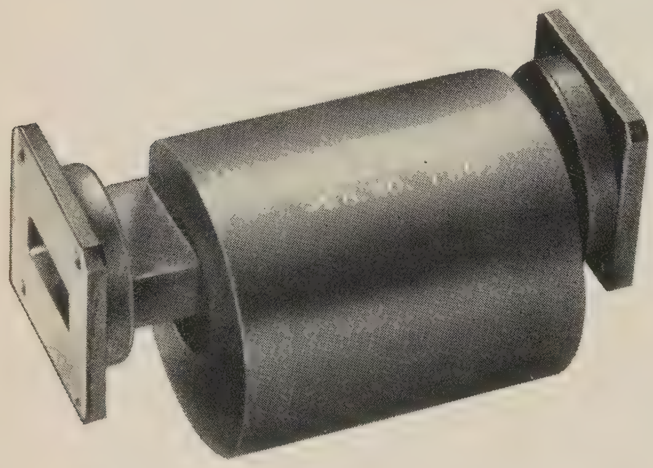
RECENT RAYTHEON DEVELOPMENTS
IN MICROWAVE FERRITE DEVICES:

X-BAND ISOLATORS FOR BROADBAND APPLICATIONS



HIGH-POWER X-BAND ISOLATOR IXH7
AVAILABLE FROM STOCK

PRICE: $175.00

TYPICAL SPECIFICATIONS
X-BAND ISOLATOR MODEL IXH7

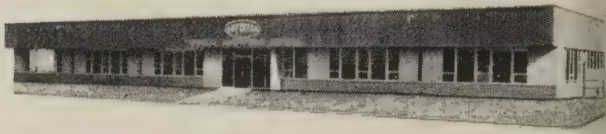
Frequency range (mc)	*8,200-12,400*
Isolation	
Minimum	*23 db*
Maximum	*30 db*
Insertion loss	
Minimum	*0.5 db*
Maximum	*0.8 db*
Power	
Peak	*25 kw*
Average	*150 watts*
VSWR	
Minimum	*1.04*
Maximum	*1.17*
Weight (max.)	*2.5 lbs.*
Max. dimension	*3.75 in.*
Flanges	*UG 39/U*
Waveguide	*RG 52/U*

COMPACT, HIGH-POWER ISOLATO PROVIDES 20 DB OF ISOLATION OVER ENTIRE BAND FROM 8,200 TO 12,400 MC

The operating characteristics of the Model IXH7 is lator are maintained at peak power levels up to 25 k over a 4.2 kmc bandwidth. Isolation is 20 db, mir mum and insertion loss is 0.8 db, maximum.

High-power broadband capabilities coupled with un sually compact design make this isolator ideally suite for microwave test equipment applications and micr wave system needs to appreciably reduce loa mismatch.

To learn more about this significant development c other important Raytheon advances in microwav ferrite devices, please write, stating your particula area of interest, to the address below.



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SPECIAL MICROWAVE DEVICE OPERATIONS
WALTHAM INDUSTRIAL PARK
WALTHAM 54, MASSACHUSETTS

In Canada, contact Raytheon Canada, Ltd.
P. O. Box 152, Waterloo, Ontario

RAYTHEON

EXCELLENCE IN ELECTRONICS

Circle Reader Service Card 19

(Continued from page 24)

e distinction, perhaps, becomes most clear when the or is a witness in a court trial. If he is testifying on cal matters, he is doing so as an "expert witness." uch, he is expected to be completely factual and im- al in his judgment of all matters within his expert petence. He was called by whichever side called him use the lawyer on that side thought his testimony d be, on the whole, advantageous to that side. How- he is expected to answer all questions, by whichever in a completely open and honest manner without rds for the benefit or harm to either side. He brings rt knowledge to the dispute. He is expected to use knowledge, as required, to his best professional com- nce.

ese are the two extremes. There is the position of awyer who, on being retained by a client, is expected rve wholly the (legal) desires of that client, without rd to any personal judgment of the relative value of e desires. On the other side there is the doctor of m it is not even proper to say that he is "employed." s "consulted." He retains full and exclusive responsi- y for all judgments rendered in the matter for which as consulted, and for whatever action implements judgment.

there an intermediate position? It is apparent that engineers try to find one. They will present their oyer's desires "up to a point," but refuse to go be- it. There comes a time when they feel it necessary xpress their opinions — even though they are opin- , not known facts — in opposition to their employer's res. To do so then gives them a feeling of virtue and aintained integrity.

hether such an intermediate position is philosophi- y justifiable or not, it is at least doubtful if it can be ntained. In the face of competition, a company cannot rd to let an engineer speak for it who limits the ex- to which he will do so. Its competition may have an neer who also has his limits, but whose limits may be her out. If both engineers have equal facility in pre- ing their cases with plausibility, there is obvious ad- age to the company with the most flexible engineer. realities of the situation will put an all-but-irresist- pressure on such an engineer to let himself become ly the professional spokesman of his employer's point.

n the other hand, an engineer who insists that the rvations must be spoken — who accepts a responsi- y to sit in judgment on technical matters, even if the gment is against his employer's desires — can be of t value to his company. It is true that what he says hurt. But once the customer comes to recognize that will speak out regardless of immediate consequence, his words take on a much greater prestige. If he something can be done, then the customer knows this statement is not based on his employer's desires, instead, on his own engineering conviction. He es to be believed and listened to.

here is, furthermore, a tendency to push this attitude

(Continued on page 30)

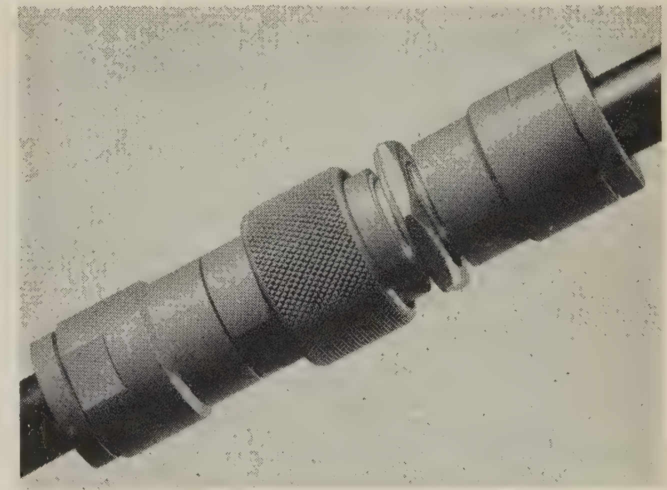
TAPCO MICROWAVE COMPONENTS

NEW

QL SERIES HIGH POWER COAXIAL RF CONNECTORS

Qualification Tested to SCL-7506 Amendment 1

These new TAPCO high-power, high-voltage RF connectors are available in straight and right angle configurations for use with RG-220/U (RG-19A/U), RG-218/U (RG-17A/U), RG-217/U (RG-14/U) and RG-189/U RF cables.



SPECIFICATIONS:

Frequency Range – DC to 5000 mc/s.
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SPECIAL FEATURES:

High voltage performance.
Meets 200-lb. pull test without performance degradation.
Sealed in mated and unmated conditions.
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Doing pulsed or "fast" circuit work?

Square Wave Generator

1 cps to 1 MC; 0.02 μsec rise time

211A Square Wave Generator. Versatile, wide range instrument for testing oscilloscopes, networks, video and audi amplifier performance, modulating signal generators, measuring time constants. Offers simple control of electroni switchers; is also convenient for indicating phase shif frequency response and transient effects.

Special features include two separate outputs — a 7 volt, 7 ohm circuit for television work and a 55 volt, 600 ohm outpu for high level work. Both outputs offer full amplitude variation. May be operated free-running or externally synchronize with positive going pulse or sine wave signal of 5 volts minimum amplitude. Compact, weighs only 25 lbs. Cabinet mode $300.00; rack mount model, $305.00.

Pulse Generator

0.07 to 10 μsec pulses, 0.02 μsec rise time

212A Pulse Generator. Time saving basic instrument fo radar, television and other "fast" circuit work, including testing rf amplifiers, filters, band pass circuits; oscilloscopes an peak measuring equipment, pulse modulating uhf signal generators. Offers positive or negative pulses of 50 watts amplitude, delay and advance sync out circuits for synchronizin to other circuits, direct-reading pulse length control, hig quality pulses with 0.02 rise and decay, flat top and minimu overshoot. Jitter less than 0.01 μsec. Permits delivery of accurate pulses to end of long transmission lines; if line is correctl terminated, pulse shape is independent of line length, syn conditions, input voltage or output attenuator setting. Interna impedance 50 ohms or less, either polarity. Repetition rat internal sync 50 to 5,000 pps, external sync approximately 2 t 5,000 pps. Cabinet model $585.00; rack mount model, $570.0

Call your hp representative for details or write direct.

Data subject to change without notice. Prices f.o.b. factory

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l-channel rotary joint

Dual-channel rotary joint

PEASE

(Continued from page 27)

to the limit, too. Such engineers will compete, willingly or not, for a reputation of uncompromising openness. The one who, in the past, has been the most insistent on expressing his reservations even at the price of making his employer unhappy, is the one who will be believed most readily, now.

It does not appear that there is an intermediate position that is stable. Whichever ethical principle is chosen, it appears that the force of competitive interaction will tend to push the employment of that principle to the limit.

An exception to this exists where separate functions are involved. A lawyer, for example, although expected to represent his employer in the most favorable manner consistent with facts, is still expected to advise his employer with the maximum use of his professional judgment. If he feels his employer to be an utter fool on some matter, he is expected to so advise him. It is only after he has so registered his judgment and found himself unable to convince his client, that he is expected to take up the job of defending his client's position with as much conviction as he can muster.

It is an ethically defensible position for an engineer to be frank to the point of brutality with his employer, and to make the best interpretation consistent with the known facts when dealing with a customer.

On the other hand, this is a rather difficult line to draw. In a large company, at least, the distinction between the customer and "higher management" is not always clear. Both are sources of money for the department. Both ha to be kept convinced that the department is competent do the job that they want done. Both have to be "sold."

It is perhaps a more practical distinction to consid content. It is quite feasible for an engineer to be ful open on the engineering evaluation of a job— probabili of success, in whole or in detail — and to maintain a di interested silence on matters of money or organizatio He can, quite easily, and without severe pressure to tl contrary, reserve his insistence on speaking his mind what he defines as engineering matters, referring all oth matters to others in administrative or executive position His reputation in the engineering field will not therel be destroyed.

What is the best answer is a question that faces eac engineer from the moment that he begins to try to fir a professional career. Like it or not, and whether the d cision is a conscious one or not, it is one of profound in portance to his life.

To the profession as a whole, it is an equally vit problem. It is an obvious fact that engineering is havin an ever increasing effect on present society. It is equal obvious that the role of the engineering profession, as whole, is, at present an ambiguous one generating a ambivalent response. Eventually, the ambiguity will b resolved. How it will be resolved will depend, partly, o the answer that the profession must finally give to th ethical problem. Eventually there will have to be som definitive answer to the question of just what are th limits of the engineer's responsibility.

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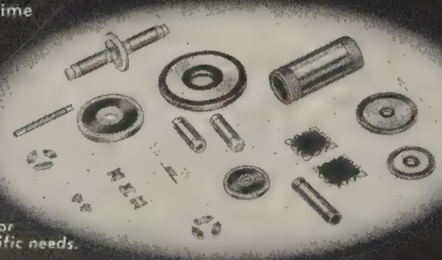

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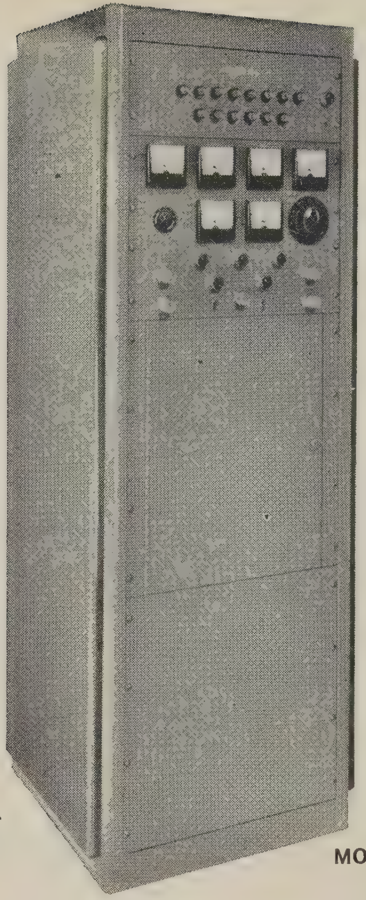
increased reliability...



MODEL 10002
35 KV

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a line of new Microwave Modulators, designed to operate kimum number of existing magnetrons, without any alterations e modulator. In addition, provision has also been made for ly converting the unit to handle any new or uncommon pulse wave tubes.

odels 10001 and 10002 are designed to handle high-power etrons with provision for internal mounting of the tube. Model 3 is designed for pulsing low-power magnetrons of the type now in beacon transmitters and for low-power commercial pulse cations.

ince all units utilize silicon rectifiers and diodes, you can expect increased life and more reliable operation. At the same time, over-all size has been considerably reduced. Every Narda Microwave Modulator is complete with built-in safety provisions, built-in meters and viewing connectors for all principal parameters, a continuously variable repetition rate, and a standard pulse width of 1 microsecond (other widths available on special order) on Models 10001 and 10002; continuously variable on Model 10003.

The specifications below indicate those characteristics of the three new models which vary from each other. The listing of features indicates those features common to all models. For additional information, and a copy of our free catalog, write to us at Dept. MJ-9.

SPECIFICATIONS

arda del #	Maximum Peak Pulse Power	Pulse Width (Microseconds)	Maximum Duty Cycle # at Maximum Power	Size H x W x D
001	18KV@20A	1*	0.001	38x22x18
002	35KV@40A	1*	0.001	67x24x24
003	4.5KV@2A	0.5-2.2†	0.002	8½x18x12

Other values of pulse width can be readily substituted.
Pulse width is continuously adjustable over given range.
Internal continuously variable trigger generator for adjusting repetition rate and duty cycle.

FEATURES

Built-in Meters:
- High voltage power supply voltage
- High voltage power supply current
- Magnetron filament supply voltage
- Magnetron filament supply current
- Clipper average supply current*

*Models 10001 and 10002

Viewing Connectors (BNC):
- Magnetron pulse voltage
- Magnetron pulse current
- Primary pulse voltage*
- Thyratron pulse current*
- PFN charging voltage*

*Models 10001 and 10002

Output sync pulses (BNC Connectors):

Positive
+ 50 v min. at 2 sec.
Negative
— 25 v min. at 2 sec.

Input sync (BNC Connectors):

Sine wave:
20 v RMS min.
Pulse:
20 v at .25 sec min.

the narda microwave corporation
HIGH POWER ELECTRONICS DIVISION
118-160 HERRICKS ROAD, MINEOLA, L. I., N. Y. • PIONEER 6-4650

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one good tur

gets another at *LEVINTHAL*

High-power pulse transformers, chokes, power transformers, and related magnetic components roll out of the Levinthal transformer department in a daily stream.

The advanced and expanding facility for producing these specialized high-quality devices is limited physically only by the present bake-out oven which is 4½ by 9 by 6 feet. As far as we can discover, there is *no* limitation on the engineering skills of the staff.

They are prepared to undertake projects in the following general categories: Pulse transformers to 600 kv with average powers of several-hundred kva, peak powers to 100 megawatts, and pulse lengths to 500 μsec; Power transformers separately or in assemblies to commercial or MIL specifications over the range 10 to 55 kv d-c and 1 to 400 kva; Filter reactors in commensurate ranges; and High-voltage low-capacitance and/or high-reactance dry-type isolation transformers from 10 to 55 kv and with outputs from 100 v-a to 6 kva.

PULSE-TRANSFORMER ASSEMBLY

Above, complex pulse package for beam-type tube, to MIL-T-27A specification. Comprises main pulse transformer, low-capacitance filament transformer, filament-current transformer, beam peak-current transformer, secondary capacitance divider, tube socket, and focus-coil mount. Ratings: 132 kv at 98 amp peak; 11 μsec at 191 pps; 3.25 μsec at 381 pps.

RECTIFIER PLATE TRANSFORMER

Center, suitable for use with various rectifiers, unit supplies 45-kv d-c, with reversible polarity, at 0.15 amp. Includes: 3-phase delta to wye rectifier transformer and 6 rectifier filament transformers.

COMPACT CHARGING REACTOR

Far left, concentrating three times the power capability of the commercial unit, behind it, into a 17-in. cube, this MIL-spec choke has Class H construction and finned case for 180 C operation. Ratings: 3.45 hy, 22.5 kv peak, 3.40 amp, 190 pps.

MISCELLANY

Other units shown include 40- and 50-kv low-capacitance filament or isolation transformers from a standard line and miscellaneous low-voltage filter chokes.

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For measurement of microwave and i.f. stability . . .

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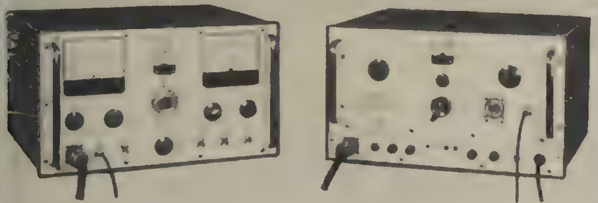
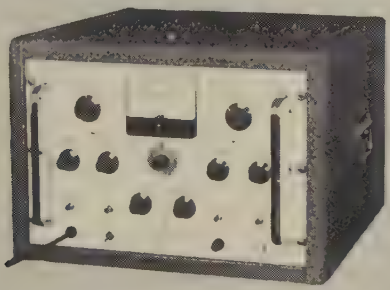
5004
Microwave Stability Tester



MODEL
5009 **Microwave Stability Tester**
(Indicator plus power supply)

. . . .

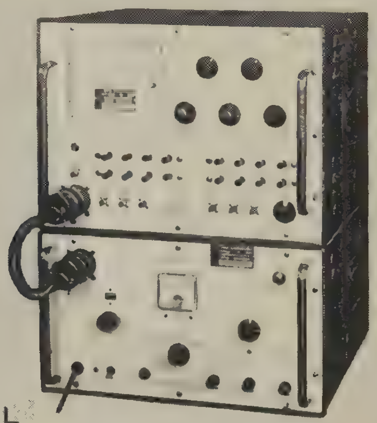
For measurement of pulse jitter in comparator . . .



MODEL
5015 **Time Stability Tester**

SYSTEM TEST APPROACH

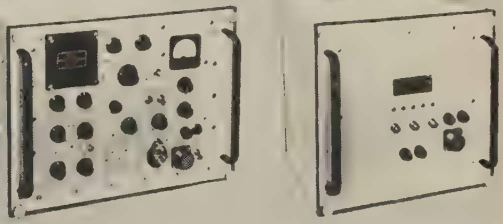
For direct db measurement of overall subclutter visibility at r.f., i.f., video . . .



MODEL
5012 **MTI Radar Tester**

. . . .

For measuring System, Receiver and Comparator subclutter visibility in X-band airborne MTI systems . . .



MODEL
5014 **MTI Radar Tester/GO-NO-GO Checker**
(Indicator plus power supply)

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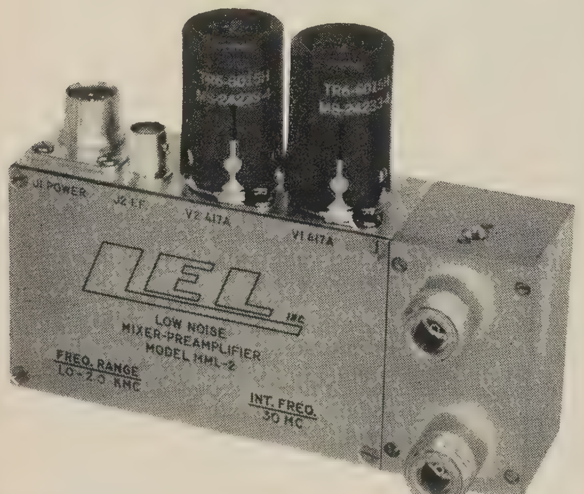

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TYPICAL SPECIFICATIONS

Noise Figure	7.5db typical
Bandwidth	8mc
Input Signal	Type "N" Coaxial
Minimum Overall Power Gain	25db
LO Power Requirement	1mw typical

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Circle Reader Service Card 28

Industry News

RADAR MANAGERS NAMED BY HUGHES GROUND SYSTEMS

Three new managerial appointments in the radar laborato at Hughes Aircraft Company's ground systems group, Fullertc Cal., were announced by Dr. Nicholas A. Begovich, assistant gro manager. Appointed to newly created positions are: Dr. Nic olas Yaru, associate laboratory manager, research and develo ment; Samuel Langberg, associate laboratory manager, produ engineering; and William R. Welty, chief scientist.

Dr. Yaru, with Hughes since 1955, previously served as he of the radar laboratory's microwave department.

Before his new appointment, Langberg served as manag product engineering department, computer laboratory; manag of administration and services department, engineering labor tories; and head of engineering services department, radar la oratory.

Welty served as manager of the circuits department, rad laboratory, and as senior scientist, technical planning offic before his new appointment. He has had 15 years profession experience in electronic circuit design and holds several paten in airborne fire-control systems, pulse modulation and tin function generators.

—*mwj*—

VEECO OPENS WEST COAST OFFICE

Veeco Vacuum Corp., New Hyde Park, N. Y., designer an manufacturer of leak detection and high vacuum equipment, h announced the opening of a new office to service Wester industry.

First of the company's Western offices has been opened i 2701 Spring Street, Redwood City, Cal., and plans are alread set for establishing new offices as required.

Announcing the new office, William R. Meoli, vice presiden said, "The installation will provide experienced engineerin assistance and factory service for our growing list of custome in eleven Western states, especially in the electronics, missil and aircraft industries."

Veeco, now in its fifteenth year, is building a new 84,00 square-foot manufacturing plant in Plainview, N. Y. Equipmen produced by the company varies from components to complet often complex, systems.

Formerly, the company was represented in 11 Western state by manufacturer's representatives.

—*mwj*—

R. T. McCOY JOINS MICROMEGA CORP.

R. T. McCoy has recently joined the technical staff of Micro mega Corp., Venice, Cal., according to E. Strumwasser president.

Mr. McCoy, an electronics engineer with 20 years' experienc will be engaged in research and development work in the fiel of solid state microwave.

Before joining Micromega, Mr. McCoy was at Hughes Aircraf where he worked on radar guidance for the advanced Falco missiles. He was an instructor in radar in the U.S. Army i 1941. In 1943, he joined the staff of MIT's Radiation Labora tories, where he was a project engineer on the Rosebud S-ban Airborne Beacon.

Mr. McCoy has also done microwave design and develop ment for RCA, MIT's Lincoln Laboratory and the Federal Tele communications Laboratory.

A specialist in doppler and moving-target-indicating rada systems, Mr. McCoy is a senior member of the IRE and holde of three patents on MTI radar and beacon systems.

—*mwj*—

HUBBARD APPOINTED BY D. S. KENNEDY

pointment of Howard H. Hubbard as tor of a newly formed Commercial owave Systems Division of D. S. edy & Co., Cohasset, Mass., has been unced by Clyde F. Mooney, company dent.

e new Division will provide complete na and tower systems for microwave unications links. Microwave links are by telephone companies, railroads and companies for transmission of TV and over long distances without installing ed system.

Division will draw upon the talents other divisions of D. S. Kennedy & he Antenna Division, in Cohasset, a g supplier of antennas and waveguide, urnish the antennas and RF equipment he projects; while Anchor Metals Di- n, Hurst, Texas, well-known supplier nsmission towers for electric utilities, provide the towers. The Division will adquartered at the Cohasset plant.

e Commercial Microwave Systems Di- n was set up after extensive market rch indicated an expanding need for owave communications apparatus, Mr. ney said. The Division will offer a lete package for microwave systems e from site survey and installation to check-out.

e director, Mr. Hubbard, formerly was Space Technology Laboratories as ger of its South Point, Hawaii, deep probe tracking station. Prior to that as chief engineer for Hycon Electron- hief of communications for the Atomic gy Commission, and communications ms engineer for RCA International ion.

—*mwj*—

L — E — CON TO BE HELD IN FEBRUARY

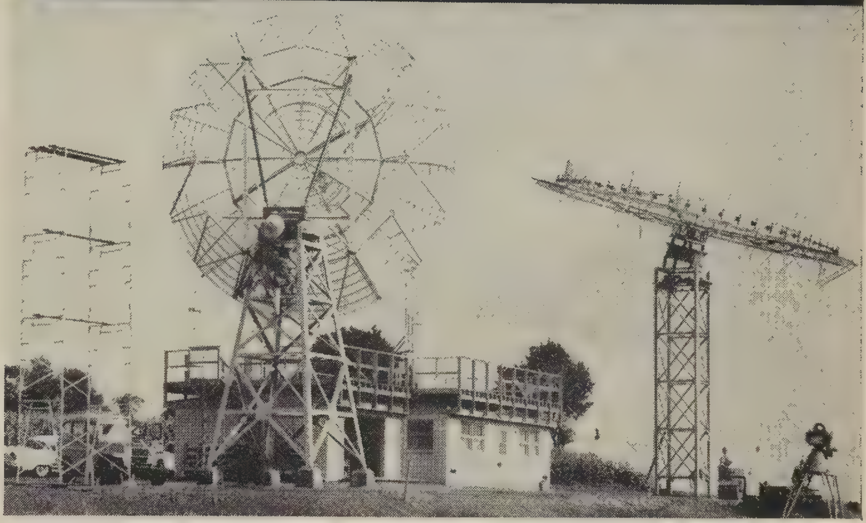
e second Winter Military Electronics ention (MIL-E-CON), will be held uary 1, 2 and 3, 1961, at the Biltmore l, Los Angeles, Cal.

is sponsored by the National Pro- nal Group on Military Electronics the Los Angeles Section, Institute of Engineers (IRE).

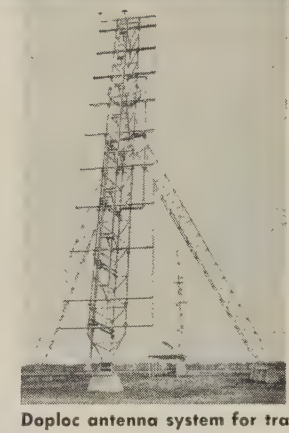
thur N. Curtiss, IRE Business Office, S. La Cienega Blvd., Los Angeles 35, is in charge of exhibits.

(Continued on page 36)

antenna
KNOW-HOW



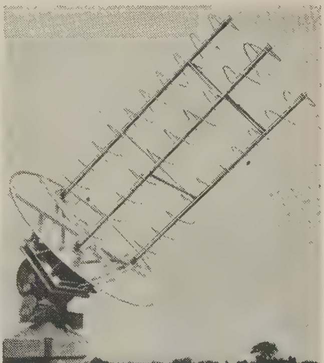
Test site where Taco antennas are performance-proved.



Doploc antenna system for tracking orbital bodies. Designed, produced and installed by Taco.

Taco offers capabilities in practically every antenna and antenna system area. These capabilities include conception, development and production, as well as field erection of antennas for all purposes. In addition, Taco offers a complete line of parabolic reflectors ranging from 4′ to 32′, along with all types of feed systems, ruggedized yagis, helical antennas with or without reflectors, airborne and submarine antennas, and complete tracking systems.

Whatever your antenna needs, check with Taco first . . .



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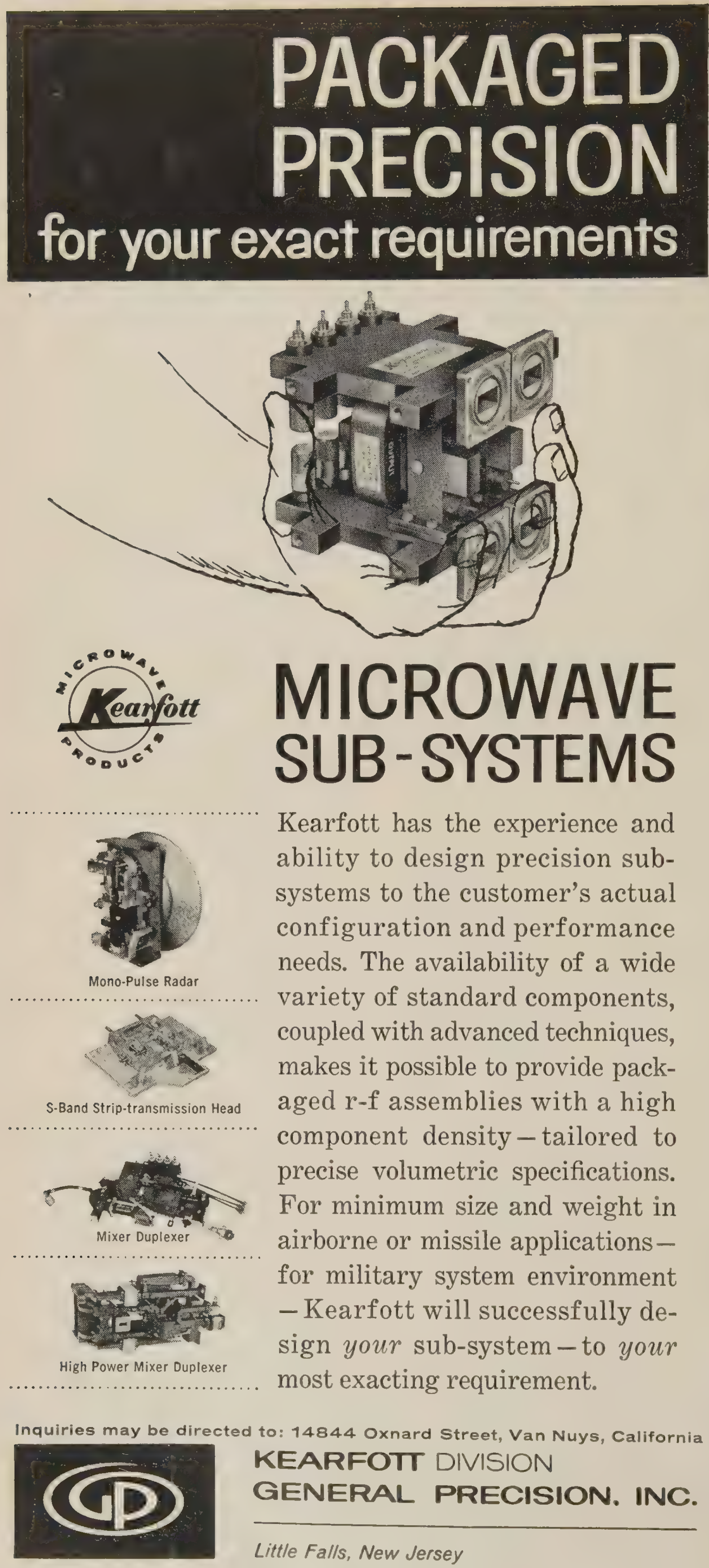

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S-Band Strip-transmission Head

Mixer Duplexer

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KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

Industry News

(Continued from page 35)

ANSOFF PROMOTED BY LOCKHEE

Dr. H. Igor Ansoff, has been name vice president of the newest subsidiar of the Lockheed Aircraft Corporation.

David F. Sanders, president of Locl heed Electronics Company, announce that Dr. Ansoff will be LEC's vice pres dent for plans and programs at heac quarters in Plainfield, N.J. The 41-yea old Dr. Ansoff will have charge of lon and short term planning, programmin and market research, effective in Augus

Since 1957 Dr. Ansoff has directe Lockheed's diversification task force, r porting to Board Chairman Robert I Gross. The group has developed a quisition opportunities, studied new ma ket areas, probed new civilian sales po sibilities, and analyzed more than 20 companies.

Dr. Ansoff participated in Lockheed' recent acquisition of Stavid Engineering a military electronics firm; Puget Soun Bridge & Dry Dock Co., Grand Centra Rocket Co., and Colby Steel and Cran companies. Earlier studies by Lockheed' development planning department, whicl Dr. Ansoff joined in 1956, formed th basis for the diversification program.

Before coming to Lockheed Dr. An soff was with the Rand Corporation fo eight years, serving as project office and conducting a series of technica studies of national defense problems Earlier he was physics instructor at th U.S. Naval Academy and at Stevens In stitute of Technology.

He received his PhD in applied math ematics from Brown University, his M in physics and ME in engineering fron Stevens, and was valedictorian of hi graduating class at Stevens. He is th author of many professional articles an has participated in numerous presenta tions to the military and to professiona and technical societies.

(Continued on page 72)

—*mwj*—

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If you want fast delivery—in *quantity*—for your retrofit program, Hughes can deliver. If you need an *advanced* tube for your development program—a field-proven tube that *meets* specifications, Hughes can deliver.

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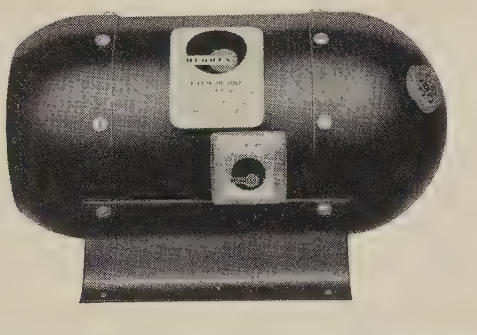
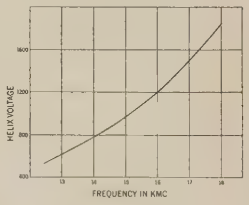
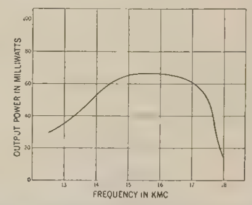
316H

K_U-BAND BACKWARD-WAVE OSCILLATOR. Electronically tunable over a frequency range of 12.4 to 18 kMc. Power output: 30-70 mw over a wide frequency range. High signal-to-noise ratio. Working temperature −55° to +90°C. Tubes are in the field with over 5000 hours' life. Formerly Model LOU-2C.

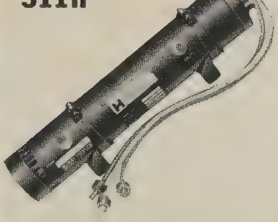


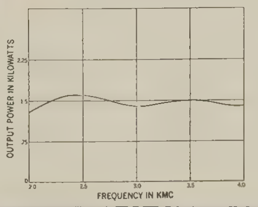


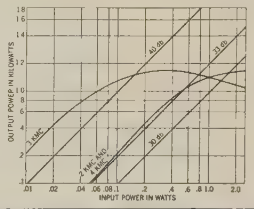


311H

S-band gridded FWA, PPM focused. 1 kw peak .01 duty. 2-4 kMc, 33 db gain. wt. 13 lbs. Formerly Model MAS-1E.

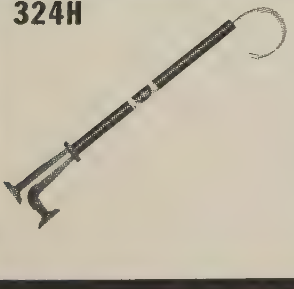


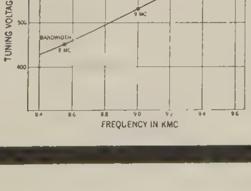


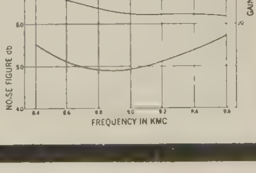


324H

X-band BWA, less than 5.5 db noise figure, 20 db gain. 10 mc bandwidth. Electronically tunable over 8.5 to 9.5 kMc. Formerly Model PAX-1.







Circle Reader Service Card 31

15 THOUSANDTHS OF A SECOND IS A VERY LONG TIME

It's much faster than you can wink an eye, yet time enough for Bell Laboratories' new high-speed switching terminal to transfer your voice to another channel while you are talking by telephone.

The new terminal—recently introduced on the trans-atlantic cable—uses the idle time in the conversations of talkers on a group of channels to provide paths for other talkers. This time-sharing technique, called Time Assignment Speech Interpolation, permits the sending of 72 simultaneous phone conversations over this deep-sea system where only 36 could be sent before.

TASI takes advantage of the fact that in a normal telephone conversation you actually talk less than half the time. You do not talk when you are listening, and even when you do talk there are pauses between sentences, words, and syllables. When there are more talkers than channels, TASI puts this idle time to use.

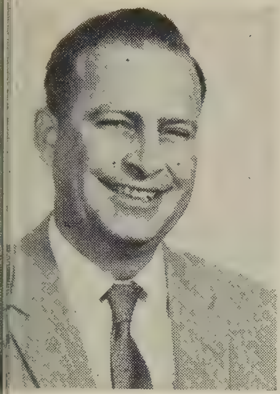
Scanning each circuit thousands of times a second, TASI instantly notices when you aren't talking, then quickly switches in someone who *is.* TASI also notices when you resume talking, immediately finds a channel not in use that moment and switches you to it. Your voice may be switched many times during a single conversation in a time too fast—about 15 milliseconds—for your ear to perceive.

The TASI switching terminal was rendered feasible by the transistor—an invention of Bell Telephone Laboratories. More than 16,000 transistors are employed to achieve the compact, dependable, high-speed circuitry required. TASI is another example of how Bell Laboratories works to keep your telephone service the world's finest.

BELL TELEPHONE LABORATORIES

World center of communications research and development

CONTRIBUTORS IN THIS ISSUE



ROBERT E. BOOTH was born in San Diego, California in 1923. He received a BS degree in electrical engineering from Stanford University.

During World War II he served three years in the Navy. After completing the radar engineering officers' program at Harvard and MIT, he served as course leader at the Pacific Fleet Electronics Maintenance School in Hawaii.

He joined Sylvania's Product Development Laboratories in Kew Gardens, New York in 1947, where he specialized in development of subminiature tubes.

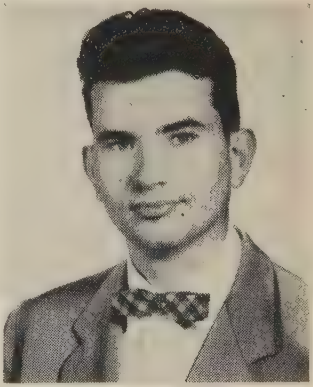
In 1953 he was transferred to the Sylvania Electronic Defense Laboratories in Mountain View, California, where he is head of the Microwave Tube and Component Section.

Mr. Booth is a member of the IRE, PGED, and PGMTT.

KENNETH J. BUTTON received a BS degree in physics in 1950, and an MS degree in nuclear physics in 1952 from the University of Rochester. He worked as a graduate assistant in the UR High Frequency Electronics Laboratory, and as research assistant in high-energy meson scattering at the UR Cyclotron Laboratory, before accepting his present position at MIT in 1952.

Mr. Button received his earliest radar experience in 1945 in association with European engineers as a member of an armed forces teaching staff at Zell am Zee, Austria. At Lincoln Laboratory, he served in 1952 as a radar engineer, assisting in the construction of the first automatic alerting radars. Since 1953, he has been engaged in the theory of microwave propagation in ferrite-loaded transmission lines and in electromagnetic propagation in tensor media, both magnetic and semiconducting. More recently, he has turned to the experimental study of excitons and energy band structure in semiconductors.

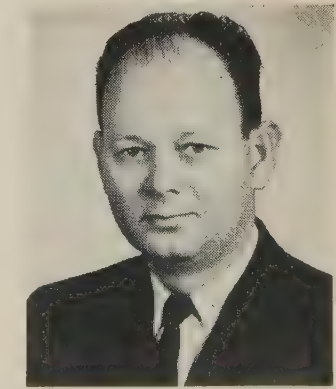
Mr. Button is a member of the American Physical Society, a senior member of the IRE and a member of the PGMTT.



RIMER CLAYTON, JR. received a BS degree in physics in 1951 and an MS
ree in physics in 1954 from the Georgia Institute of Technology. From 1951 to
7 he worked at the Georgia Tech Engineering Experiment Station where he
icipated in the development of experimental radar systems and oceanographic
ruments, in operational analysis studies of radar systems, and in research in
rowave spectroscopy.

Ie joined the staff of Scientific-Atlanta, Inc., in 1957 and is now assistant
ctor of the engineering division. His primary fields of interest have been
tronic circuitry and instrument design.

Ir. Clayton is a member of Sigma Xi, Phi Kappa Phi, Tau Beta Pi, Sigma Pi Sigma
the IRE.



RCY J. HOLLIS was born in 1918 at Collier, Georgia. He received a BS degree
950 and an MS degree in electrical engineering in 1956 from the Georgia In-
ute of Technology.

uring the war he was active in the radar field, first as a civilian, and later in
Navy. From 1948 to 1959 he worked in the development of high-speed scan-
g antennas at the Engineering Experiment Station at Georgia Tech where he
Assistant Head of the Radar Branch. This interval also included experience in
erwater sound, meteor scatter propagation, microwave component development,
radar systems design.

rom 1954 to 1959 he was a consultant to Scientific-Atlanta, Inc. on antenna
surements techniques. On February 1, 1959 he joined the staff on a full-time
s and is now vice-president of engineering.

Ir. Hollis is a member of Eta Kappa Nu, Tau Beta Pi, Phi Kappa Phi, Sigma Xi
the IRE.

(Continued on page 41)

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Radio Interference Laborator

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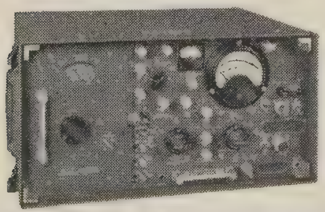

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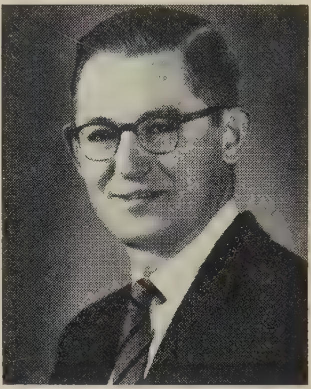
BENJAMIN LAX was born in Hungary on December 29, 1915 and came to country in August, 1926. In 1937 he went to Cooper Union on a four-year arship, receiving a BS degree in mechanical engineering in 1941. In 1942 he was ted into the Army as a private and went through OCS, then radar school at ard and M.I.T. He was a radar officer assigned to M.I.T. Radiation Laboratory 1944-46. In 1946 he became a consultant for Sylvania Electric Co. prior to ing graduate school that fall at M.I.T., where he received his PhD in physics in . In November of 1951 he joined the Solid State Group at Lincoln Labora- and in 1953 he became head of the ferrites group. In 1955 he became of the Solid State Group. In 1957 Dr. Lax became associate head of the Com- ications Division at Lincoln in charge of solid state physics in several laboratory ps and was appointed head of the Solid State Division when it was established 58. Dr. Lax has also been appointed director of the new M.I.T. Magnet Labora- as of July, 1960.

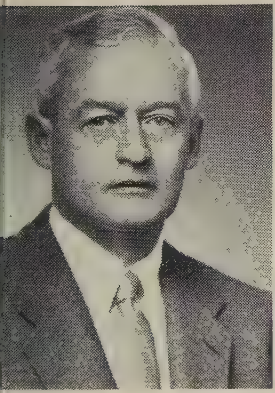
r. Lax was recipient of the 1960 Oliver E. Buckley prize by the American ical Society for his fundamental contributions to microwave and infrared roscopy of semiconductors. He is a fellow of the American Physical Society a member of the Executive Committee of the Solid State Division, the Solid Advisory Panel of the Office of Naval Research. He was associate editor of ournal of Applied Physics from 1957-1959, is an associate editor of the Physical ew and the *microwave journal,* and a member of Sigma Xi.



STANLEY J. MILLER was born in Lewiston, Maine, on June 29, 1927. He received BS degrees from the University of Maine in general engineering and electrical engineering in 1949 and 1950 respectively, and an MS degree in electrical engineering from the University of Michigan in 1951.

From 1951 to 1955 he was employed by Sylvania Electric Products, Inc., on the design of microwave tubes. During 1955, he worked for Westinghouse Electric Corp. as a design engineer on magnetrons and other microwave components. In 1956, he joined the MIT Lincoln Laboratory where he was concerned with the development of high-power duplexers and other microwave devices. In September, 1957 he became associated with Microwave Associates as a group leader in its Switching Devices Department. In September, 1958 he rejoined Lincoln Laboratory where he is again concerned with the design and development of high-power microwave components.

He is a member of Tau Beta Pi, Phi Kappa Phi and the IRE.



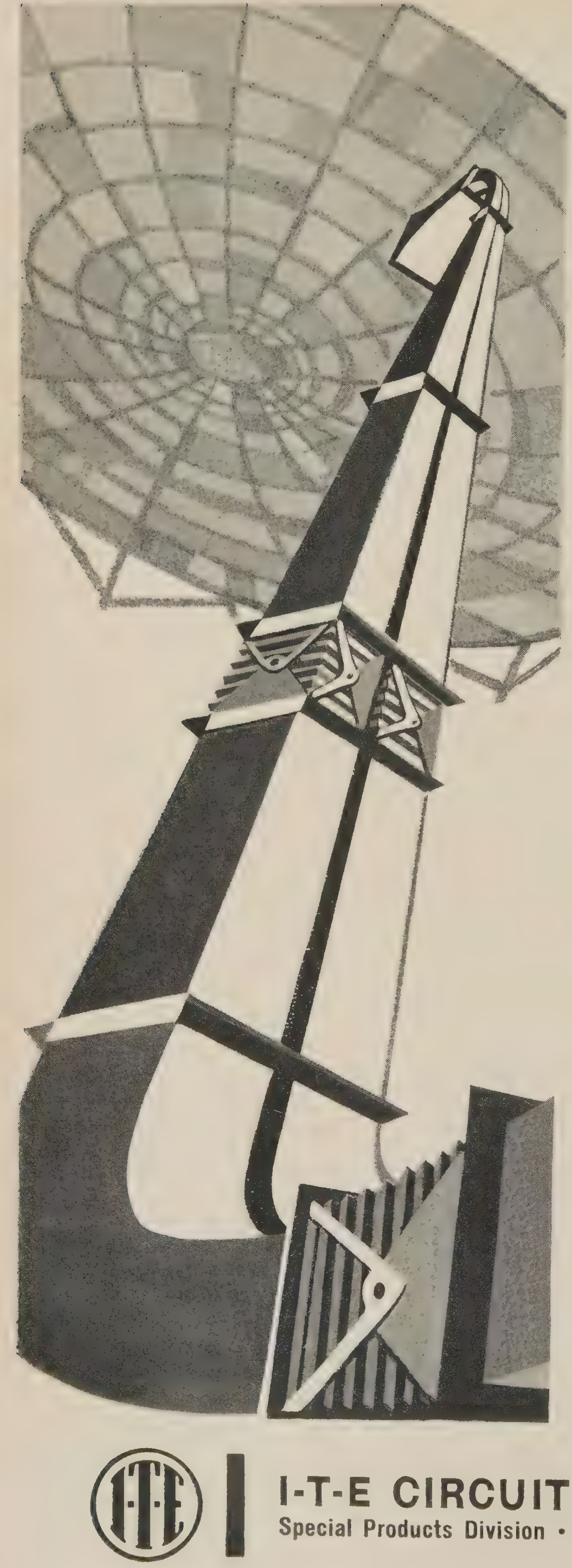
W. HARDIE SHEPARD is a partner in Payson & Trask, New York, N.Y., a venture capital firm engaged in investments for capital growth and specializing in prefabricated housing, electronics and chemicals. He is currently directing investments in electronics and is responsible for many such investments in New England, New York and other areas.

Prior to joining Payson & Trask, Mr. Shepard was secretary-treasurer and director of the Perkin-Elmer Corp., Norwalk, Conn. Earlier he was associated with Lehman Brothers investment banking firm. During World War II Mr. Shepard was with Hazeltine Electronics.

He is a director of nine electronic and scientific companies including Trans-Sonics, Inc., Burlington, Mass., Fairfield Engineering Corp., Saddle Brook, N.J., and Trygon Electronics, Inc., Roosevelt, Long Island, N.Y.

BERT G. VELTROP was born in Taos, Missouri, on December 24, 1932. He ived a BS degree in electrical engineering in 1954 from the University of souri. He then joined the Electronic Defense Laboratories of Sylvania Electric ducts, Inc., as an engineer in the Microwave Section. Two years were spent in Army where he served as a Project Engineer conducting tropospheric scatter pagation studies. In October, 1956, he returned to EDL and continued his rowave work of tube evaluation and applications while taking a year of gradu- work at Stanford University.

t present, Veltrop is a senior engineer engaged in the design and development nicrowave components. He is a member of Tau Beta Pi and Eta Kappa Nu.



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lectromagnetic Properties of
FERRIMAGNETICS AND THEIR APPLICATIONS
From UHF to Millimeter Waves

BENJAMIN LAX and KENNETH J. BUTTON
LINCOLN LABORATORY*
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Lexington • Massachusetts

FIRST OF THREE PARTS

Developments during the past three years in both the experimental and theoretical studies of ferrimagnetic aterials in waveguides have encompassed a broad range of activities. It is no longer appropriate to refer to this ld as "microwave ferrites," as in the past, because nonreciprocal devices now exist which use ferrimagnetic rnet materials and antiferromagnetic materials. Furthermore, the frequency range of application is not restricted the microwave range but extends throughout both the UHF and also the millimeter wave region. The review some of these most recent accomplishments which follows will be concerned not only with the fundamental vances in the understanding of ferromagnetic materials, but also with the application of this knowledge which s resulted in the invention and development of new and improved devices. A large portion of this paper will so be devoted to the description of the principles of operation and the performance characteristics of a number these UHF, microwave and millimeter wave components.

PART I

WAVE PROPAGATION IN FERRITE LOADED STRUCTURES

angular Waveguide
undamental Waveguide Mode
nomalous Gyromagnetic Modes
errite-Guided Modes
reciprocal Coaxial Structure
able Cavity Resonator

PART II

SPIN WAVES

Wave Spectrum
netostatic Modes

LINE WIDTH IN FERRIMAGNETS

of Spin Waves
of Impurities

NONLINEAR PROPERTIES OF FERRITES

monic Generation
ration of the Spin System
omagnetic Amplifier
lectromagnetic Operation
odified Semi-static Operation
ongitudinal Pumping
ain-Bandwidth
rowave Power Limiter

PART III

FERRITE DEVICES IN UHF BANDS

Low-Field Magnetic Losses
Aluminum-Doped Ferrites
High-Power Devices
Three-Port Circulator

RECIPROCAL PHASE SHIFTER DEVELOPMENTS AT MILLIMETER WAVELENGTHS

High-Anisotropy Ferrites
Three-Port Circulator
Antiferromagnetic Devices

I. INTRODUCTION

Some of the advances in research covered by this review constitute important breakthroughs into undeveloped areas formerly inaccessable because of the need for fundamental exploration. Other advances have involved the more complete development of topics that have been pursued successfully for several years. A major item of the latter category has been the theoretical problem of wave propagation in waveguides containing ferrites. The anomalous gyromagnetic modes in rectangular guide and nonreciprocal propagation in simulated coaxial line have received recent attention. A new problem that has now been managed successfully is the solution for the tunable resonant modes of ferrite loaded cavities.

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*erated with support from the U.S. Army, Navy, and Air
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From a fundamental viewpoint, our knowledge of spin waves and their importance in ferromagnetic resonance phenomena has been clearly established with the use of a simultaneous theoretical and experimental approach. Their contribution to the ferrite resonance loss mechanism has been identified. Some of this has been possible only through the discovery and subsequent experimentation with the new garnet materials which have permitted a more detailed examination of the nature of magnetic losses at microwave frequencies. There is now a clearer understanding of the nonlinear behavior of ferrites and garnets under conditions of high signal power. This has led to the development of high-power isolators and to the invention of entirely new devices such as the ferromagnetic amplifier, the harmonic generators and the microwave power limiter.

A genuine breakthrough has occured in applications with the invention of millimeter devices such as isolators and circulators at wavelengths as short as two millimeters. High frequency isolators which require unusually large dc magnetic biasing fields have, until recently, utilized the high-anisotropy uniaxial magnetic oxides having large internal fields. Today, however, the use of antiferromagnetic materials having internal fields from fifty to hundreds of kilogauss permit nonreciprocal devices to be operated from the millimeter well into the far infrared range.

The conventional isolators and circulators have been extended to operate in the UHF region in both rectangular guide and coaxial line through the use of garnets and aluminum-substituted ferrites. The invention of the ferrite Y-circulator has provided a compact device which has demonstrated its usefulness in both the UHF and mil meter wave region. Finally, much higher performance now available in fast, electronically-controlled microwa switches and reciprocal ferrite phase shifters for anten scanning applications.

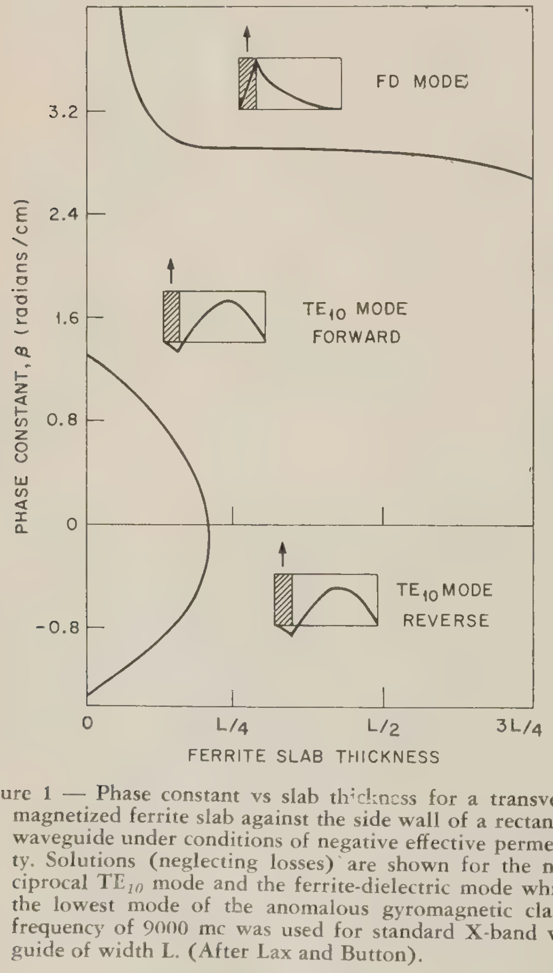
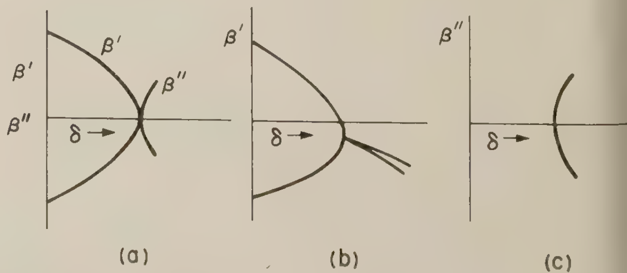


Figure 1 — Phase constant vs slab thickness for a transversely magnetized ferrite slab against the side wall of a rectangular waveguide under conditions of negative effective permeability. Solutions (neglecting losses) are shown for the nonreciprocal TE_{10} mode and the ferrite-dielectric mode which is the lowest mode of the anomalous gyromagnetic class. A frequency of 9000 mc was used for standard X-band waveguide of width L. (After Lax and Button).

II. WAVE PROPAGATION IN FERRITE-LOADE STRUCTURES

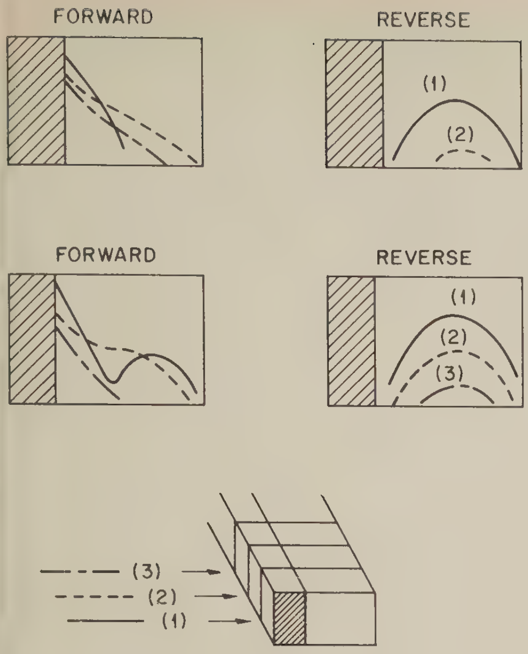
The earliest theoretical treatments of propagation ferrite-loaded transmission lines dealt with the set modes propagating in cylindrical waveguide containi an axially-magnetized ferrite rod[1] and also the fundame tal TE mode in rectangular waveguide containing a fe rite magnetized transversely to the direction of propag tion. Although the electromagnetic theory for the cyli drical waveguide developed a more complete set of mode the solution for rectangular waveguide[2] proved to be mo amenable to numerical evaluation.[3] This theory has r cently led to the discovery of a new class of modes i digenous to ferrite-loaded waveguide and has also provide a physical interpretation in terms of their unique fie patterns. It is now possible to classify three varieti of propagating modes that can exist in a rectangular wav guide containing a transversely-magnetized ferrite sla The first category contains the fundamental mode whic may be distorted by the ferrite slab in such a way as t introduce nonreciprocal propagation. These may be calle the *waveguide modes.* The second class are unidirectiona modes. Since each of these propagates only in one dire tion, they have no analog in empty waveguide or in guide containing an isotropic medium. They arise as consequence of the tensor properties of the gyromagnet medium. The lowest mode of this class is a TE mode an has been called the "ferrite-dielectric" mode. The highe modes of this *anomalous gyromagnetic class* are not purel TE nor TM but have additional cartesian components c the microwave electric and magnetic field. The final clas of modes are also neither TE nor TM but they are nc unidirectional. They propagate in both the forward an reverse directions and the propagation constant is non reciprocal. Unlike the distorted waveguide modes, th electromagnetic energy is contained largely within th ferrite slab and their existence depends upon the slal thickness. Therefore, we shall designate these as *ferrite guided modes.*

Nonreciprocal propagation in coaxial transmission lin has also been described by theoretical consideration of th TEM mode distorted by dielectric loading. The boundar value solution of the simulated loaded coaxial line ha



(a) (b) (c)

Figure 2 — The propagation constant vs slab thickness 6 for th TE_{10} mode under conditions shown in Figure 1 for (a) ordi nary waveguide cutoff; (b) and (c) ferrite-loaded guide Although losses are neglected, a complex propagation con stant B' + jB" is obtained indicating an evanescent mod beyond "cut-off". (After C. T. Tai).



re 3 — Experimental determination of the relative rf electric field intensity in a ferrite loaded waveguide for two slab thicknesses, showing the evanescent waveguide mode propagating in the reverse direction and the ferrite dielectric mode in the forward direction. The thicker slab (top) quenches the waveguide mode more effectively. (After Angelakos).

ided the field patterns, and the nonreciprocal phase has been calculated for both the UHF and microwave ons.

Rectangular Waveguide

he technique of solving propagating mode problems ectangular waveguide involves the substitution of an umed field pattern into Maxwell's equations and the sequent matching of boundary conditions at the walls the guide and at the ferrite-air interface. Since the ution takes the form of a transcendental equation and computations are usually complicated, the problem ften solved for one class of modes at a time.

damental Waveguide Mode—The phase constants for ward and reverse propagation in the nonreciprocal eguide mode are shown[4] at the lower left of Figure 1. the slab thickness is increased, the phase constants for h directions approach zero and the calculated electric d pattern shown in the inset appears to be crowded an effectively smaller guide. At a critical thickness, phase constants go to zero and the mode is cut off. wever, the theoretical solutions for the TE_{10} mode e been extended into the "cut-off" region by C. T. Tai,[5] he has shown that the propagation constant becomes plex proving that the waveguide mode is not actually off in the usual sense but becomes evanescent. Where- in the absence of ferrite (Figure 2a), the solution be- nes purely imaginary at cut-off, the solutions for a fer- slab in a waveguide (Figures 2b and c) have a real imaginary part.

he experimental consequences [6, 7] of this behavior are wn in Figure 3. The relative rf electric field intensity been mapped through the use of a small transverse robe inserted in the top of the guide at points in the ee planes shown. The waveguide mode (reverse propagation) is evanescent and the penetration is shallower for the thicker slab. Forward propagation takes place in the "ferrite-dielectric" mode which is the unidirectional solution at the top of Figure 1.

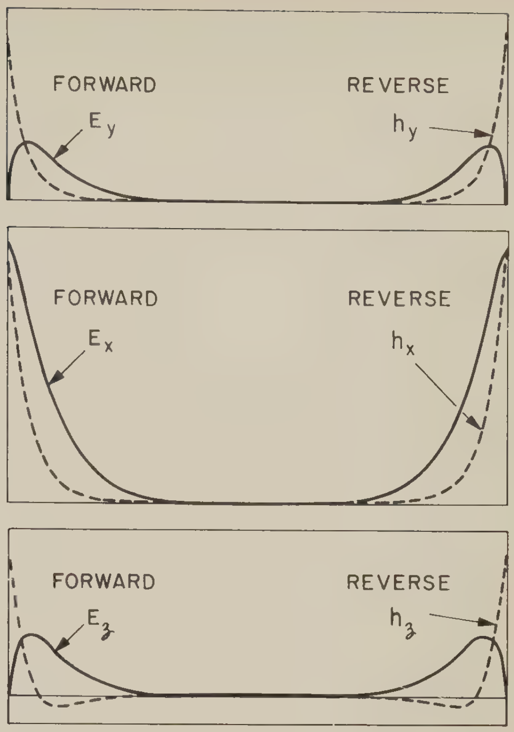


Figure 4 — The field patterns for a ferrite-metal mode in waveguide completely filled with ferrite. The field intensities are for forward propagation and at the other side for reverse propagation. This would be a uni-directional mode if the ferrite were in contact with only one wall. (After Barzilai and Gerosa).

Anomalous Gyromagnetic Modes—The higher modes of this class will propagate even in arbitrarily small completely-filled waveguide when the effective permeability of the ferrite is negative. The problem of propagation in a rectangular guide completely filled with ferrite was formulated by Mikaelyan[8] and in the parallel-plate analog by Van Trier.[9] The general form of these solutions took into account the birefringent character of the ferrite and did not restrict the solutions to simple TE or TM mode patterns. Seidel[10] has recently applied this type of formulation to the guide containing a slab against the wall and given the physical and analytical interpretation of anomalous unidirectional mode propagation. These modes have now been classified by Seidel and Fletcher.[11] They simplified the problem considerably by confining their attention to arbitrarily small guide in which only higher unidirectional modes propagate, all others being cut off. Thompson[12] had previously demonstrated the existence of this phenomenon experimentally. Seidel found solutions where the electric field reached a maximum within the ferrite near the metal wall of the guide. A linear combination of such birefringent rays permitted the boundary condition at the metal wall to be satisfied. Then, using the small-guide restriction, the following explicit expression for the phase constant, β, was obtained for the "ferrite-metal" (FM) modes:

$$\beta = \frac{1}{\kappa}\,\frac{m\pi}{d}\left(\frac{\mu\kappa^2}{\kappa^2-\mu^2}\right)^{1/2} \qquad \text{FM modes}$$

where μ and κ are the diagonal and off-diagonal components of the ferrite permeability tensor. The distance d denotes the waveguide height, and the order m of the mode is defined as the number of half cycles of sinusoidal variation along the direction of the transverse dc magnetic field; $m=0$ are the TE modes which are not admitted by the small-guide restriction. Figure 4 shows a plot made by Barzilai and Gerosa[13] of field patterns for a mode of this sort for the guide completely filled with ferrite. If some of the ferrite were removed from contact with either the right or left wall, this mode would propagate only in one direction. A plot of the phase constant for several FM modes for half-filled guide is shown in the upper part of Figure 5. The FA (ferrite-air) modes shown are those which have the peaks of their field patterns at the interface between ferrite and air in the half-filled guide. Again, Seidel and Fletcher discovered these by satisfying the boundary conditions with linear combinations of only those solutions which have a peak intensity near the interface. These restrictions resulted in the following remarkably simple expressions for the phase constant for each type of "ferrite-air" mode:

$$\beta = -\frac{1}{\kappa}\cdot\frac{m\pi}{d}\left(\frac{\mu\kappa^2}{\kappa^2-\mu^2}\right)^{1/2} \qquad \text{FA I}$$

$$-\kappa\beta = \left[\left(\frac{m\pi}{d}\right)^2+\beta^2\right]^{1/2} + \mu\left[\frac{1}{\mu}\left(\frac{m\pi}{d}\right)^2+\beta^2\right]^{1/2} \qquad \text{FA I}$$

It should be noted that the FM mode propagates in one direction while propagation in the other direction takes place via the FA I mode.

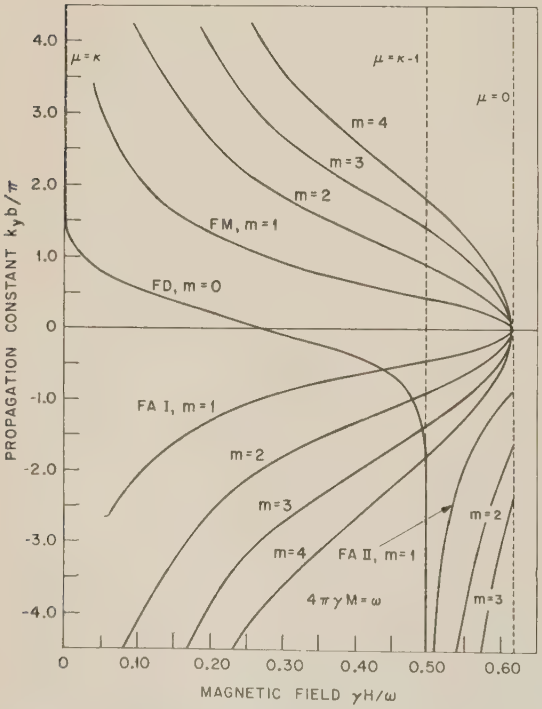


Figure 5 — Typical anomalous gyromagnetic mode spectrum in half-filled small guide as a function of magnetic field. (After Seidel and Fletcher).

Ferrite-Guided Modes — Figure 6 shows the phase co stant *vs* ferrite slab thickness obtained from the gener solution carried out by Barzilai and Gerosa.[14] As t slab (against the left wall) is made thicker, the ferri guided modes begin to appear and, at the slab thickne designated by the two black dots, the field patterns this mode have the form shown in Figure 7. The micr wave energy is concentrated largely within the ferrit This is neither a TE nor TM mode because all comp nents of both the electric and magnetic fields exist. The modes do not depend upon the guide width but on the sla width and unlike the unidirectional modes which prop gate in arbitrarily small guide, these can be cut off making the slab (or the guide) sufficiently small.

Nonreciprocal Coaxial Structure

The TEM mode of coaxial transmission line is unsui able for nonreciprocal ferrite devices unless the mode ca be distorted sufficiently to create a rotating rf magneti field vector. Since this has been accomplished recently coaxial circulators and ferrite resonance isolators ar available in the UHF bands which have the compact broadband (and low power) characteristics of coaxia line. It was shown by Seidel[15] that it is possible to develo a nonreciprocal structure in coaxial line by distorting th azimuthal symmetry of the TEM mode with adielectri and thereby generate a longitudinal component of the r magnetic field. The two magnetic components form vector which rotates as the wave pattern moves along th line. When a transversely-magnetized ferrite is placed i this region of the rotating rf magnetic field, nonrecipro

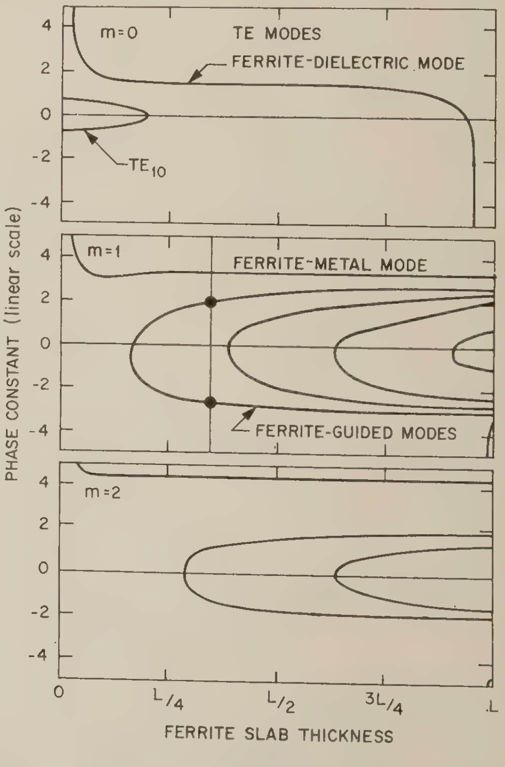
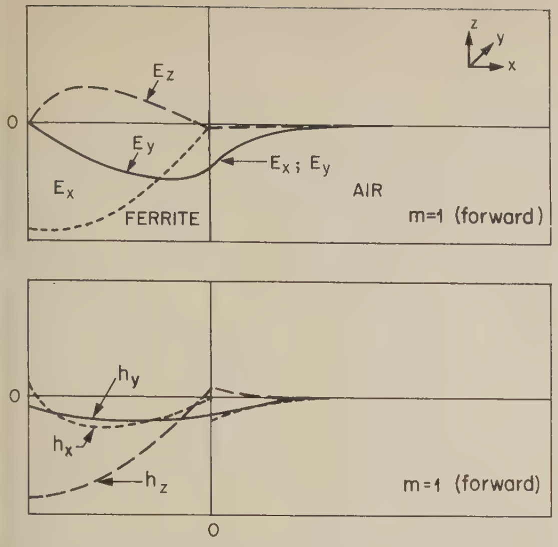
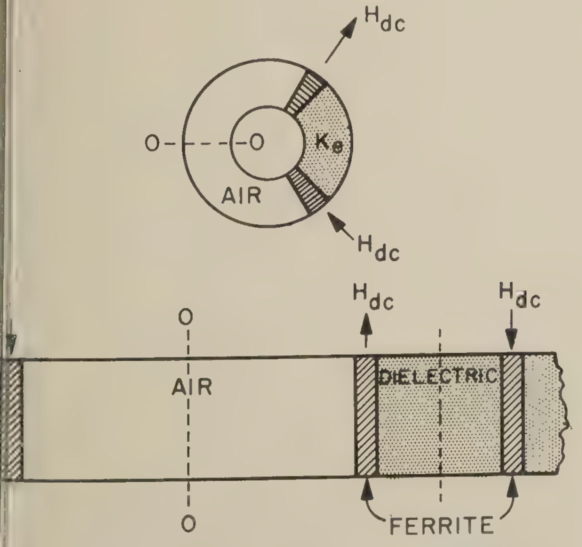


Figure 6 — Phase constant as a function of ferrite slab thickness showing the three classes of modes propagating in ferrite loaded rectangular waveguide. The solutions were obtained for a frequency of 9000 mc, for standard X-band waveguide of width L. (After Barzilai and Gerosa).



e 7 — Microwave field patterns of a ferrite-guided mode or forward propagation only under the conditions denoted by the two black dots in the previous figure. (After Barzilai and Gerosa).

e experienced. Nonreciprocal attenuation has been nstrated experimentally by Duncan, Swern, Tomi- and Hannwacker.[16] The analytical problem for the rocal coaxial phase shifter containing a small ferrite was formulated by Sucher and Carlin [17] by making f the parallel plate analog of the coaxial line. They ned a small nonreciprocal effect because the ferrite has a relatively large dielectric constant which dis- the TEM mode. When a material of relatively large ctric constant K_e is enclosed by the ferrites as shown gure 8 the field distortion is greatly enhanced. Numeri- lutions of the boundary value problem in the simulated al line shown in the lower part of Figure 8 were car- out by Button[18] who obtained differential phase shifts rge as one radian per centimeter of line length at mc as shown in Figure 9. The differential phase shift all if the TEM mode is only slightly distorted by r a small amount of dielectric or a small dielectric constant. The effect also drops off precipitously if the amount of dielectric is too large because nearly all of the microwave energy is concentrated within the dielectric with little remaining in the region where the ferrites are located. Of course, larger amounts may be used at longer wavelengths. The results of the boundary value solution have been used to plot the field patterns within the loaded line as shown in Figure 10. The peak of the electric intensity occuring within the dielectric creates a gradient in the transverse electric field which does not exist in the



e 8 — The cross-section of the ferrite nonreciprocal coaxial phase shifter (upper figure) showing the dielectric loading, K_e, and two transversely magnetized ferrite slabs. The infinite parallel plate analog is constructed by slitting the line at 0-0 and unrolling it (After Button).

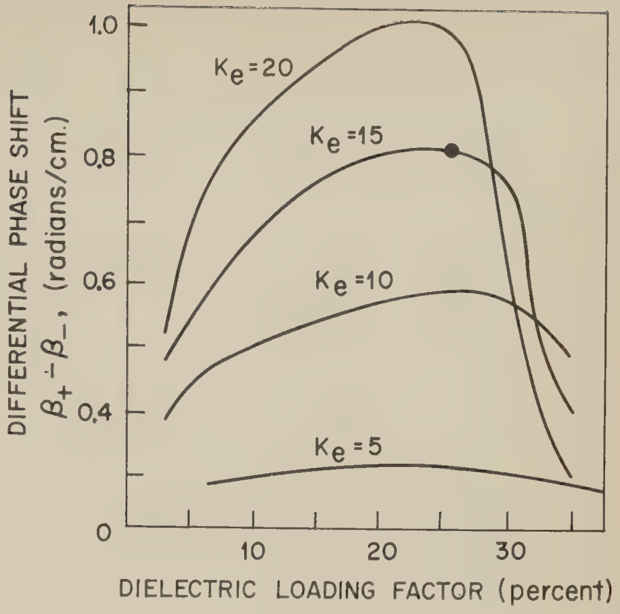


Figure 9 — Theoretical differential phase shift vs amount of dielectric at a frequency of 2000 mc for a 1 5/8 inch diameter coaxial line. Smaller amounts of dielectric must be used for large K_e to avoid the dielectric-waveguide effect. (After Button).

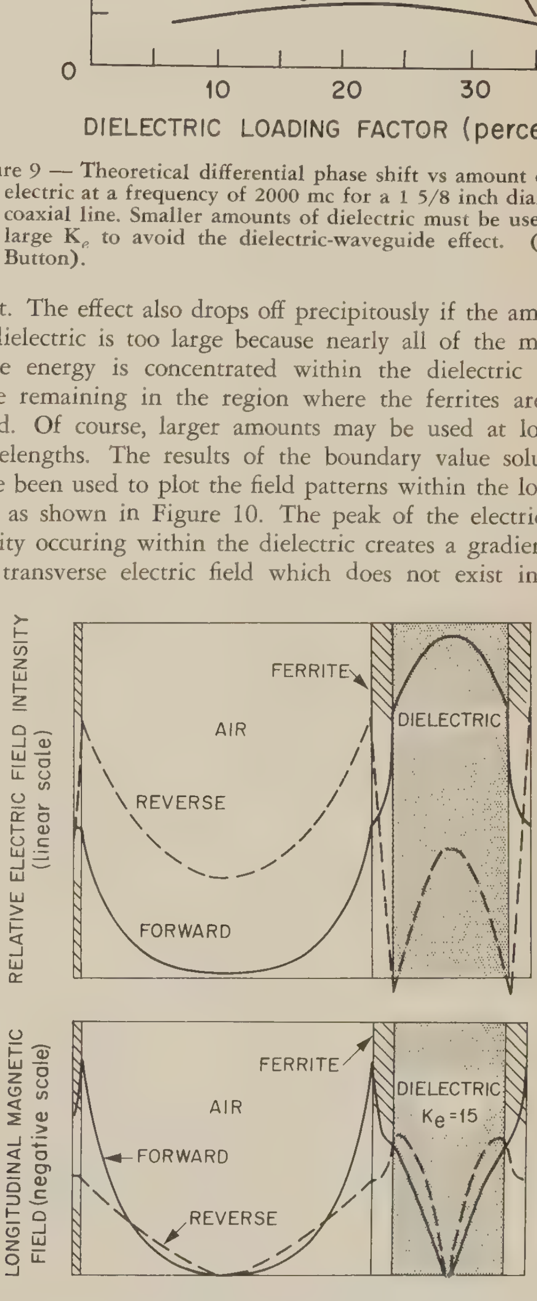


Figure 10 — The transverse rf electric field intensity (upper figure) for the nonreciprocal coaxial phase shifter. The longitudinal component of the rf magnetic field, which does not exist in empty coaxial line, combines with the transverse magnetic component (not shown) to provide the rotating magnetic vector needed for nonreciprocal effects. (After Button).

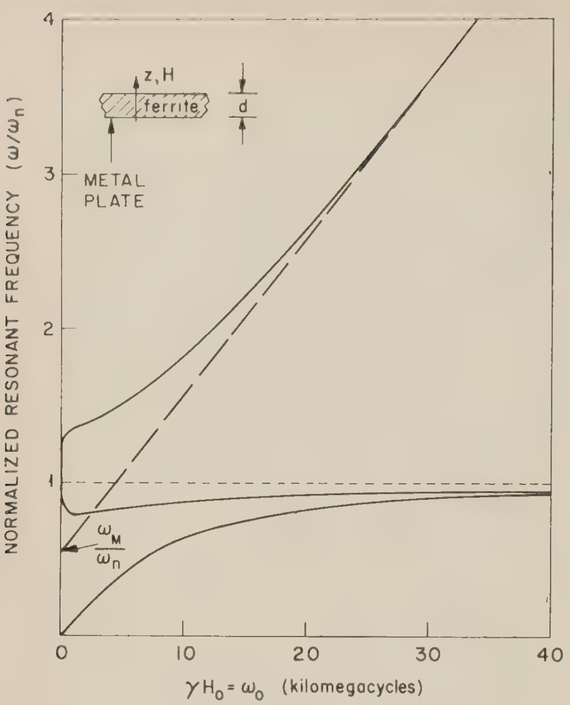


Figure 11 — The resonant frequencies (normalized by the zero-field resonance) for the completely-filled infinite parallel-plate cavity shown in the inset. The frequencies have been plotted as a function of dc magnetic field intensity for the magnetic field perpendicular to the plates from the cubic equation of Equation 3.

undistorted TEM mode. This gives rise to a large longitudinal magnetic component near the interface which is needed for the ferrite to exhibit nonreciprocal properties.

This numerical solution has been extended to the UHF region by Boyet, Weisbaum and Gerst[19] who have made calculations of the nonreciprocal phase shift in coaxial line loaded with ferrite and dielectric and have found that a circulator can be constructed at 400 mc which would be only five inches long. They have also shown that the external dc magnetic field can be adjusted to achieve broadband characteristics.

The Tunable Cavity Resonator

The resonator frequency of a cavity containing a ferrite can be tuned by varying the external dc magnetic field applied to the ferrite. If the cavity is to contain more than about one percent ferrite by volume, the resonant frequencies of the cavity modes will vary over a wide range as a function of external field and the mode patterns will be distorted substantially. The essential features of the cavity problem, including the resonant frequencies, can be obtained from the simplest possible case shown in the insert of Figure 11 or Figure 12. This is an infinite slab of ferrite bounded by two infinite metal plates. Since the component of the electric field parallel to the plates must vanish at the conducting surfaces, we must have a field of the form $E = E_0 \sin k_z z$ where $k_z = n\pi/d$. The familiar form of the dispersion relation from Maxwell's equations reduces to

$k_z^2 = \frac{\omega^2}{c^2} K_e \mu_{eff}$ where μ_{eff} is the dimensionless "effective permeability" of the ferrite composed of the elements of the permeability tensor. Thus the solution of the problem is given by

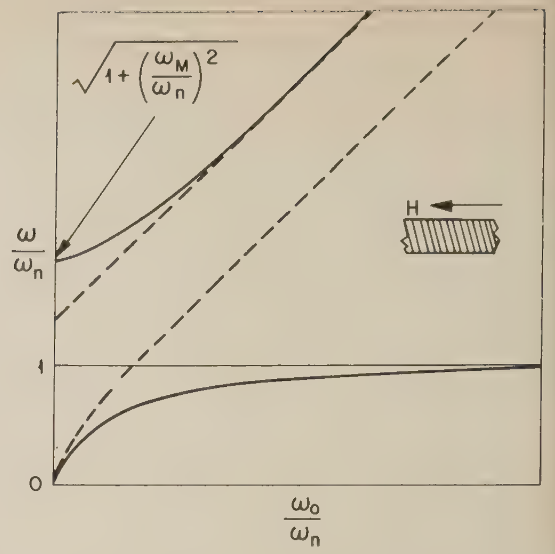


Figure 12 — The normalized resonant frequencies as a functi of applied field for the dc magnetic field parallel to t metal walls of the completely-filled infinite parallel-pla cavity shown in the inset. These are the two roots of t biquadratic of Equation 4. (After Heller).

$$k_z^2 = \frac{\omega^2}{c^2} K_e \mu_{eff} = (n\pi/d)^2 = \frac{\omega_n^2}{c^2} K_e \qquad (1$$

or

$$\omega^2 \mu_{eff} = \omega_n^2$$

where ω_n is the resonant frequency of the cavity at zer field where the medium within the cavity is unmagnetize and is then characterized only by its dielectric constan K_e. For the case shown in Figure 11 where the extern field is perpendicular to the plates, $\mu_{eff} = \mu\pm = 1 +$ $[\omega_M/(\omega_0 \mp \omega)]$ and Equation (2) becomes

$$\omega^2 \left[1 + \frac{\omega_M}{\omega_0 \mp \omega} \right] = \omega_n^2 \qquad (3$$

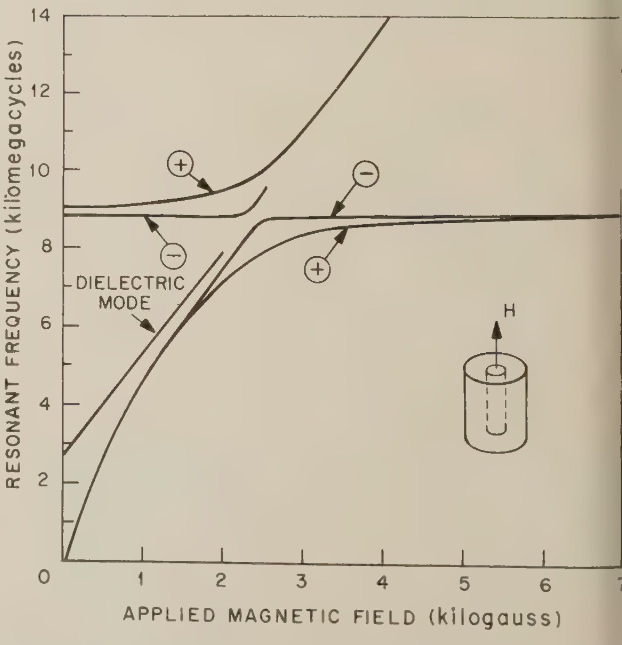


Figure 13 — The exact solutions for the TM_{110} mode in a c lindrical cavity containing a thin axial ferrite rod with ratio of rod to cavity diameter of 0.1 The positive and neg tive rotating mode solutions and the ferrite-dielectric mod (extreme left) are shown. (After Heller).

ω_M and ω_o are proportional to the ferrite magne- on and the applied field, respectively, and ω is the ant frequency of the cavity in the presence of a The three modes of resonance (as a function of ed field) which are solutions of this cubic equation nown in Figure 11.

the same parallel-plate cavity has the external field ed parallel to the plates as shown in Figure 12, it is necessary to substitute into Equation (2) the effec- permeability for a ferrite magnetized transverse to direction of propagation which yields a biquadratic ion in ω:

$$\omega^4 - \omega^2 \left[(\omega_o + \omega_M)^2 + \omega_n^2 \right] + \omega_n^2 \, (\omega_o^2 + \omega_M \omega_o) = 0 \qquad (4)$$

plot of the two roots of this equation as a function of agnetic field intensity is shown[20] in Figure 12.

e latter parallel-plate analogy applies directly to the lem of the TM modes of both the completely-filled ngular cavity[21] and the completely-filled cylindrical y where ω_n, in each case, represents the appropriate field solution for the particular geometry. For ex- e $\omega_n{}^2 \rightarrow \omega_{l,m}{}^2 \propto (l\pi/a)^2 + (m\pi/b)^2$ for the rectangular cavity. Heller[20] has pointed out that the TM_{lm0} modes of the cylindrical resonator containing an axially-magnetized ferrite rod have a relatively simple solution because these are the modes with field components independent of the height of the cylinder. Thus, with the axial dc field parallel to the cylindrical walls the resonant frequencies should be similar to Figure 12. Heller's results for the TM_{110} mode of the cylindrical cavity containing a longitudinally magnetized thin axial rod of ferrite are shown in Figure 13. Here the solutions split for each sense of rotation of the mode when l is not equal to zero. Heller has also plotted field patterns,[20] worked out results for higher TM_{lm0} modes and observed satisfactory agreement with experiments for the TM_{010} mode. The one distinction between the partially-filled and completely-filled cavity is the existence of the ferrite-dielectric mode shown in Figure 13, which is analogous to that found in waveguide.

NEXT MONTH — Spin Waves, Line Width in Ferrimagnetics, Nonlinear Properties of Ferrites.

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The TRAVELING WAVE RESONATOR
And
HIGH POWER MICROWAVE TESTING

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A comparatively new and interesting circuit element, the traveling wave resonator, presents the microwave engineer with a number of possible applications[1,2,3,4]. The application to be considered here is its use as a high power simulator. The traveling wave resonator or ring resonator, permits one to test transmission components with a pure traveling wave and at field levels considerably above those usually available to the designer.

The traveling wave resonator may be qualitatively examined with the aid of Figure 1. A re-entrant transmission line is coupled to a second transmission line through a directional coupler which will be considered to be ideal, that is a coupler with infinite directivity. A wave progressing from the signal source is partially coupled into the ring and proceeds around the ring in the direction indicated. When this wave passes the coupling region, a small fraction is coupled into the main transmission line with the remainder proceeding around the ring again. At the same time, more energy is being coupled from the main line into the ring. If the wave proceeding around the ring and the wave coupled into the ring are in phase at the coupled section, then it is evident that the wave in the ring can be reinforced and can, in fact, become quite large in magnitude. This brief discussion shows three factors that must be considered in a practical resonator. First, the length, l, of the ring must be such that the waves will be in phase. This means that the length of the ring or the frequency of the source or both must be variable. Second, the coupling to the ring should be variable to compensate for losses in the ring and thereby control the magnitude of the resultant wave. A third and not so obvious requirement is that some method of matching out any backward wave should be provided. The importance of this will be demonstrated in this analysis which follows.

The schematic circuit in Figure 2 shows the transmission line coupled to the ring by a directional coupler and terminated in a matched load. The ring is formed b two lengths of line, l_1 and l_2, which connect the tw port device under test to the coupler. The referenc planes are indicated by the numbers in the circles. Th assumption of a matched load is used to simplify th analysis but is not restrictive since a mismatched loa could be considered by the superposition of solution obtained by having the appropriate input signals at port 1 and 3.

The analysis of this circuit can be easily performed t yield some very interesting results.** Assume first that th two port device is not present so that reference planes 5 and 6 are coincident. That is, the ring is a simple smooth, re-entrant transmission line. Under these conditions, and assuming an ideal directional coupler, two properties of the ring circuit itself can be derived. The forward wave in the ring, that is the waveput of port 4, b_4, normalized with respect to the input at port 1, a_1 can be written as follows

$$\frac{b_4}{a_1} = j \frac{C}{1 - T\sqrt{1-C^2}\, e^{-j\beta l}} \qquad (1)$$

where $j = \sqrt{-1}$

C = voltage coupling coefficient of the directional coupler

T = voltage transmission coefficient of the ring transmission line and is equal to $10^{-A/20}$ where A is the attenuation in decibels around the loop

β = the phase constant of the ring transmission line

$l = l_1 + l_2$, the total length of the ring.

Equation (1) is maximized when $\beta l = 2n\pi$, (n = 0,1,

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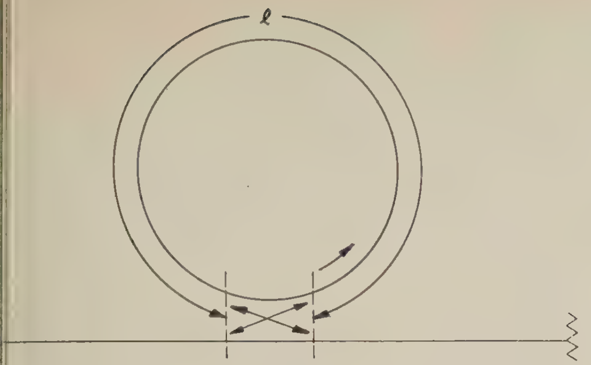
* Operated with support from the U.S. Army, Navy, and Air Force.

**Detailed analysis can be found in Reference 8.



ure 1 — Simplified traveling wave resonator circuit.

If the ratio $\frac{b_4}{a_1}$ is called the field multiplica-
factor or gain, M, then at resonance

$$M = \frac{C}{1-T\sqrt{1-C^2}} \qquad (2)$$

relationship contains two of the three requirements n were stated in the introduction. The gain is clearly ndent upon (1) the ability to resonate the structure n through a length or frequency variation and, (2) elationship between the coupling into the ring and ss in the ring. The latter point is more evident if ain is optimized for a particular loss. It can be n that the optimum gain occurs when $C=\sqrt{1-T^2}$ ecomes

$$M_{opt} = \frac{1}{\sqrt{1-T^2}} = \frac{1}{C_{opt}} \qquad (3)$$

desirability of having a variable coupler, if compo- s differing greatly in loss are to be tested, is thereby onstrated. If uniform loss components are to be evalu- then a fixed coupler would be a reasonable economi- ompromise between optimum gain and simplicity.

uation (2) is plotted in Figure 3 with the locus of tion (3) indicated by the dashed line. From these es, several points may be observed. If a fixed coupler be used, it is seen to be advantageous to be over- led rather than undercoupled. Some gain will be ficed for low-pass components, but a more generally ul resonator will result. It is also evident that a ring nator is not very useful when the ring loss is greater 2 db ($T \approx 0.8$). It should also be noted as a rule humb for use of a fixed coupler with low-loss com- nts that a maximum gain of 6 db above the coupling icient can be obtained provided the coupler has 10 r looser coupling.

he wave transmitted past the coupling section to the normalized with respect to the input for the case r consideration is given by the following equation

$$\frac{b_3}{a_1} = \sqrt{1-C^2} - \frac{C^2T}{1-T\sqrt{1-C^2}} \qquad (4)$$

re b_3 = wave out of port 3
a_1 = input wave at port 1

first term is the magnitude of the wave normally smitted past the coupler. The second term is due to wave injected into the main line from the ring in a phase as to cancel part of the transmitted wave. particular interest is the wave transmitted to the

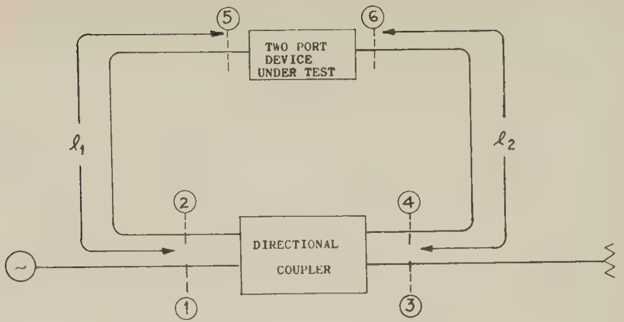


Figure 2 — Circuit to be analyzed.

load when optimum multiplication is obtained. In this case, $C_{opt} = \sqrt{1-T^2}$, equation (4) reduces to zero. Thus, at optimum coupling there is no power transmitted to the load. This allows a resonant ring, properly coupled to a transmission line to be used as a frequency rejection filter[3].

By proper substitution in Equation (1), the Q of the ring resonator can be derived. At critical coupling, the Q is given by

$$Q = \frac{\pi N\left(\frac{\lambda_g}{\lambda}\right)^2}{\arccos\left(\frac{4T^2-T^4-1}{2T^2}\right)} \qquad (5)$$

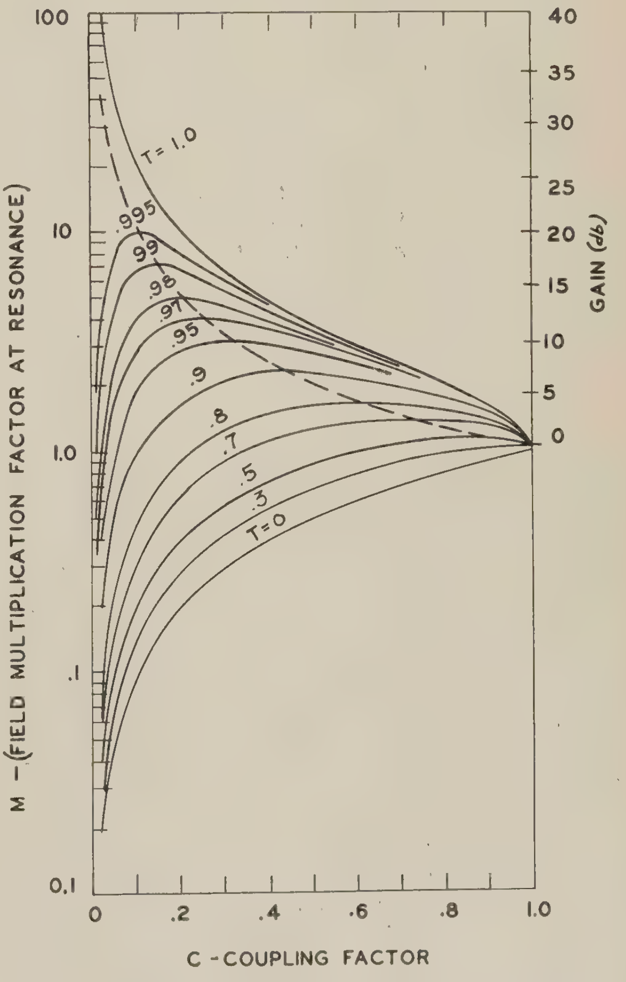


Figure 3 — Gain as a function of coupling factor for a simple ring.

where N = number of integral guided wavelengths in the ring
λ_g = guided wavelength
λ = free space wavelength

As the loss becomes small, the Q rises very rapidly and values of several thousand may be obtained. This has a direct bearing upon the power gain which can be obtained with a pulsed source.

Now let us analyze the case in which there is a two-terminal, lossless discontinuity between ports 5 and 6**. In this situation, the device under test may be characterized as having a reflection coefficient of $\Gamma e^{-j\rho}$ and a transmission coefficient of $\sqrt{1-\Gamma^2}\, e^{-j\gamma}$. In this notation Γ is real and is the magnitude of the reflection coefficient. ρ and γ are the phase angles of the reflected and transmitted waves respectively. It can be demonstrated[5] that $\gamma - \rho = \pm \pi/2$.

For this case, the result for the forward wave in the ring normalized to the input becomes

$$\frac{b_4}{a_1} = jC \frac{1 - T\sqrt{1-C^2}\,\sqrt{1-\Gamma^2}\, e^{-j\phi}}{1 - 2T\sqrt{1-C^2}\,\sqrt{1-\Gamma^2}\, e^{-j\phi} + (1-C^2)T^2\, e^{-j2\phi}} \qquad (6$$

where $\phi = \beta l + \gamma$

It is seen that gain now is a rather complicated function of ring loss, electrical length, coupling and reflection coefficient. For given conditions of C, T and Γ, it is found that gain maximizes for two conditions of ring length or frequency.

When the reflection in the ring is small, the gain maximizes when $\phi = 2n\pi$. As the reflection coefficient increases, the gain is a double valued function with frequency with the peaks in the gain given by

$$\phi = \text{arc cos}\ \frac{1}{2}\Bigg[T\sqrt{1-C^2}\,\sqrt{1-\Gamma^2} + \frac{1}{T\sqrt{1-C^2}\,\sqrt{1-\Gamma^2}} \qquad (7)$$
$$-\Gamma\sqrt{T^2(1-C^2) + \frac{1}{T^2(1-C^2)(1-\Gamma^2)} - 2}$$

The gain is plotted in Figure 4 as a function of the frequency parameter when C = 0.316 and T = 0.9 (10 db coupler, ~ 1 db ring loss). It is seen that the behavior of the gain is analogous to that of coupled tuned circuits as the coupling between them is varied. In this case, the coupling is between the forward and reverse waves in the ring. Equation 6 is plotted in Figure 5 as a function of T for several values of Γ, when C = 0.5.

In principle, a ring resonator can be used to measure the high power insertion loss of a transmission device. If the gain is measured first with a calibrating section of line in the ring and then with the device to be tested in place, the change in gain could be a sensitive measure of loss, particularly at high gains. This assumes, however, that there is no difference in reflection coefficient between the calibrating section and the unit to be tested. Figure 5, the dashed lines will help to illustrate the ty of error which can be encountered. If the ring has transmission factor of .98 and a reflection coefficient .07 with a calibration section in place, the gain would 2.84. If, however, the reflection coefficient is neglecte one would assume the ring has a transmission coefficie of .952. If the device to be measured is inserted into t ring and decreases the transmission coefficient to .96 b at the same time reduces the reflection coefficient to .0 the improper interpretation indicates a transmission c efficient of .948. Thus a device having a 0.2 db inse tion loss is measured to have a 0.04 db insertion loss. Th losses here are small but, in the case of extremely hig power systems, can become very important in terms heating effect. The example chosen indicates an interpr tation of the measurement which gives an apparent lo lower than the true value. It is equally true that loss considerably greater than the true value could be indicate

In the case being considered, there is a mismatch withi the ring which causes a backward wave. Just as a forwar wave is multiplied, so is this backward wave. The resul is two-fold: a very high standing wave may be establishe within the ring, and an extremely large mismatch may b presented to the source driving the ring. Considering th first point, the reflection coefficient looking into the rin at port four is given by

$$|\Gamma_{in4}| = \frac{T'\,\Gamma}{1 - T\sqrt{1-C^2}\,\sqrt{1-\Gamma^2}} \qquad (8)$$

where T' = transmission coefficient of length l_2 (magnitude) and when $\phi = 2n\pi$.

Under the conditions that Γ is small, the loss is low and optimum coupling is obtained.

$$|\Gamma_{in4}| \approx M_{opt}{}^2\Gamma \qquad (9)$$

It is therefore entirely conceivable that $|\Gamma_{in4}|$ could be unity. A backward wave of this magnitude could cause considerable error in the determination of the peak power-handling capability of a component.

The very high backward wave which may be present in the ring will also make its presence known at the transmission line input to the ring. Analysis will show that the input reflection coefficient to the ring is given by

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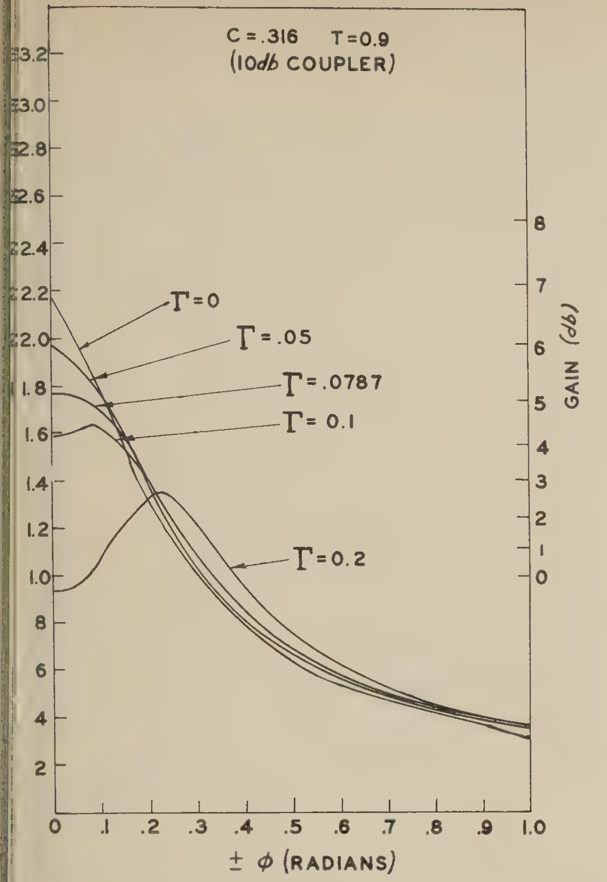
** The results presented here are similar to those of Tomiyasu in Reference 6 except that he did not consider the loss factor.



e 4 — Frequency dependence of gain in a mismatched ng.

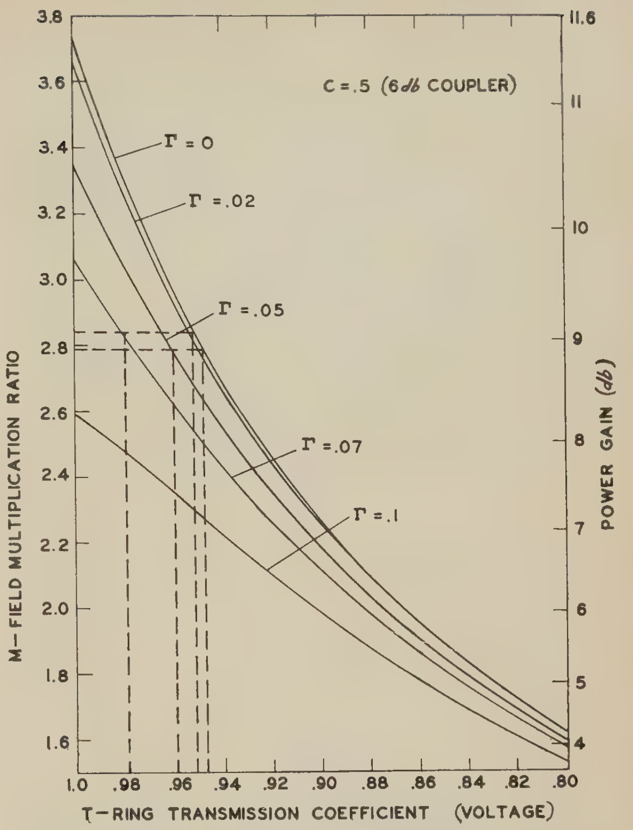


Figure 5 — Gain as a function of transmission coefficient for a mismatched ring.

$$|\Gamma_{in1}| = \frac{-C^2\Gamma T' e^{-j(\rho+\beta l_2)}}{1-2T\sqrt{1-C^2}\,\sqrt{1-\Gamma^2}\,e^{-j\phi}+(1-C^2)\,T^2\,e^{-j2\phi}} \qquad (10)$$

e all terms are as previously defined. If once again olve for the maximum value as a function of ϕ, we find ima occur when $\phi = 2n\pi$ and

$$= \text{arc cos}\left\{\frac{\sqrt{1-\Gamma^2}\,[1+T^2(1-C^2)]}{2T\sqrt{1-C^2}}\right\} \qquad (11)$$

input reflection coefficient is also a double value tion of ϕ. However, the input reflection coefficient imizes at different values of ϕ from those at which gain maximizes. These results are plotted in Figure 6 he same conditions at which the gain was plotted.

f perhaps even greater interest is the input reflection ficient at resonance as a function of the reflection coient within the ring. This result which is plotted in re 7 shows the very great amplification of input misch which results. This amplification and its variation es it almost mandatory to include an impedance cher within the ring. Attempting to tune a mismatched when one is using a magnetron or a properly pred klystron as a source is indeed a challenge. The use solators, if they are available, will help this situation.

he wave delivered to the load suffers many of the e effects noted above. Its behavior is pictured in re 8.

he discussion above has been a theoretical one based wo special cases. In practice, it is not possible to have a single, discretely located discontinuity. There exists around a practical ring, a large number of discrete and distributed discontinuities in the form of flange-to-flange joints, bends, etc. Despite this difference, the concepts presented in the theory are valid and the various effects must be considered.

The construction and performance of the traveling wave resonator operated by Group 46 at Lincoln Laboratory will be examined in some detail in this part of the paper. This resonator is constructed of WR 2100 waveguide. Driven by a QK508 magnetron, it has produced simulated power levels of 100 Mw peak, 200 kw average, at approximately 425 mcps.

Figure 9 shows schematically the Group 46 traveling wave resonator. It is seen that the device incorporates (1) a variable directional coupler made up of the three hybrids and the ganged, short-circuiting plungers in the lower center of the figure, (2) an impedance transformer in the form of the hybrid and its two independently varible short-circuiting plungers located at the right of the figure, and (3) a phase-length adjustment in the form of the hybrid and its two ganged short-circuiting plungers located at the left of the figure. Thus, the three basic elements which were postulated in section one are present. A point of interest is that the phase shifter and impedance matcher are ganged back-to-back so that the phase of the

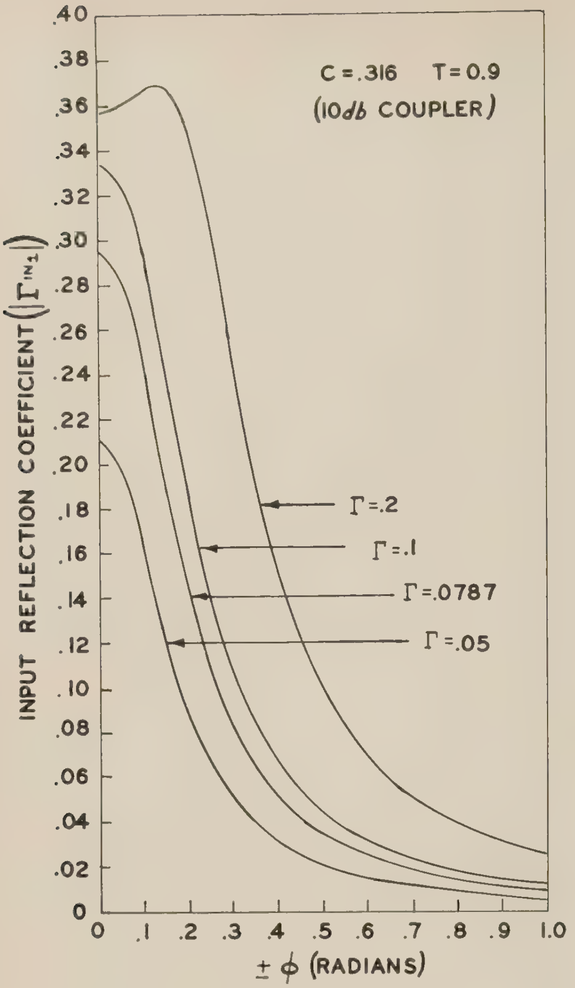


Figure 6 — Input reflection coefficient of a mismatched ring as a function of frequency parameter ϕ.

impedance matcher can be varied while maintaining the electrical length of the ring constant. It should also be noted that sufficient sampling couplers are included to allow optimum adjustment of all parameters. The various plungers are motor-driven, remote-controlled units because of their size and weight. There is also a variable power divider between the RF power source and the input to the ring. This allows the coupling, match and length of the ring to be adjusted for optimum performance at any desired input power level. The device under test can then be studied as the input power level is varied.

Figure 10 is a picture of the ring itself. The resonator is large, not only because of the waveguide size, but also because sufficiently long runs were incorporated so that any component to be tested could be conveniently inserted without having to rebuild the ring completely. The ring measures about 40 feet in length with about 100 feet of waveguide in the active portion. It is housed in a 40′ x 60′ building near the laboratory proper, so that adequate space for the movement of large components and for the power supplies, modulators, heat exchangers and other ancillary equipment is available. The hybrids for the phase shifter and impedance matcher are discernible in the lower level of the ring. In the middle of the lower level are located the remote control motors for these variable units. Figure 11 shows in greater detail th ganged variable shorts used in the phase shifter, impedance matcher and variable directional coupler. Thes

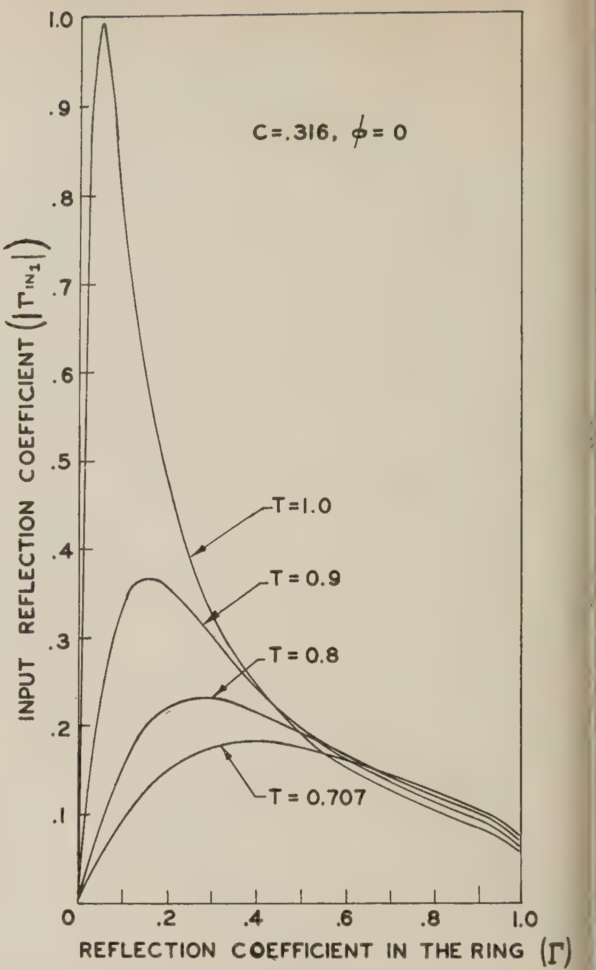


Figure 7 — Input reflection coefficient at resonance as a fun tion of mismatch in the ring.

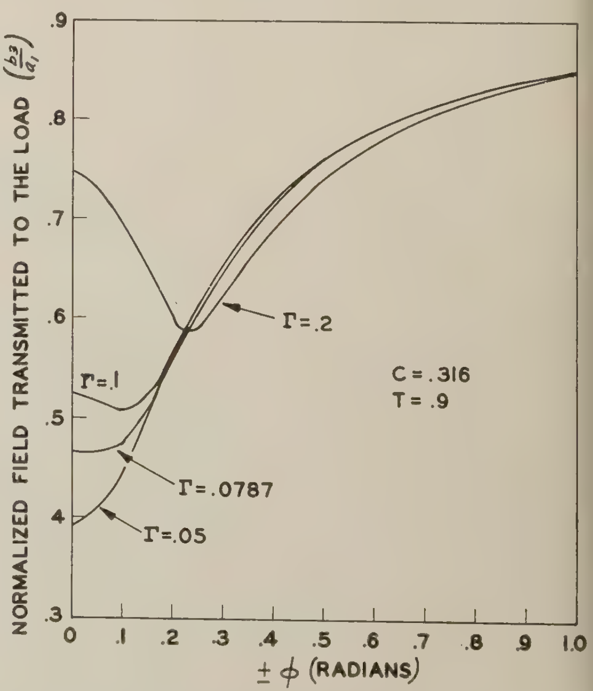
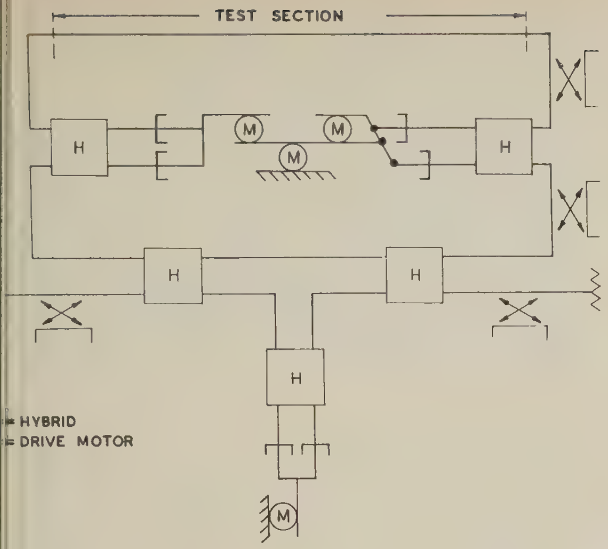


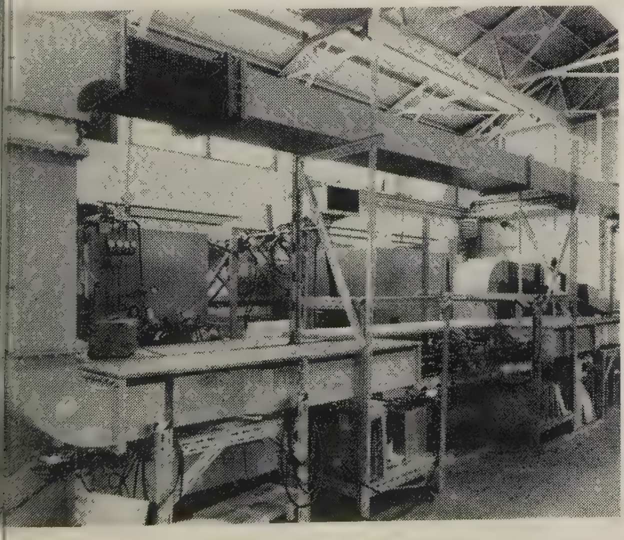
Figure 8 — Field transmitted to the load in a mismatched rin as a function of frequency parameter ϕ.



ure 9 — Schematic representation of group 46 traveling wave resonator.

ible, box-type shorts have a VSWR in the order of
db.

The pulse shapes and spectra which one observes at
ferent points in the ring are shown in Figure 12, a
otograph of the input, forward and output wave of
ring. These pictures were taken using the same de-
tion system and padding the ring forward wave to
intain the same voltage at the detector. It is seen
the input wave has the normal shape of an RF pulse.
e ring forward wave requires some explanation. The
e and fall portions of the wave are consistent with
at one would expect for the charging and discharging
a high-Q resonator. It is seen that the pulse length of
e driver is not sufficient to charge the ring completely.
he wave transmitted to the load can be explained as
llows: the ring cannot be charged instantaneously so
at initially all the power is transmitted to the load. As
e ring forward wave builds up, the power to the load
creases (to zero if critical coupling is obtained). When
e drive pulse terminates, the ring discharges into the load
e to the directional properties of the coupler.



igure 10 — Group 46 traveling wave resonator.

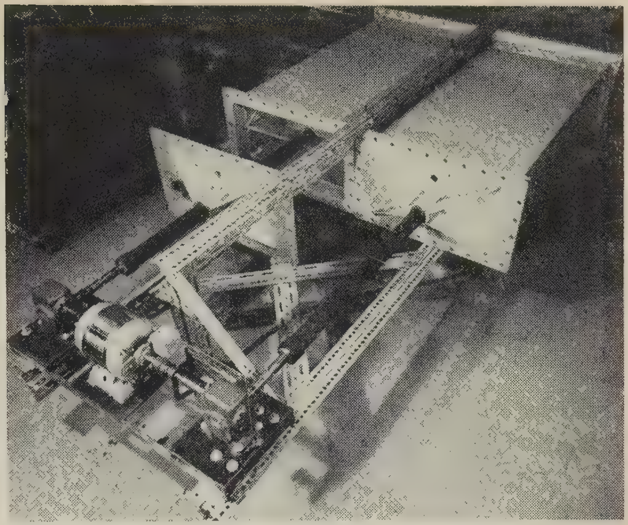


Figure 11 — Detail of variable plungers.

Figure 13 shows the spectra of the driver pulse, ring forward wave, and load wave. These may be interpreted as representing a plot of average power density versus frequency. The driver spectrum is shaped slightly by the fact that the two power dividers in the system were set for loose coupling, so that a low-Q cavity existed between them. Nevertheless, it is typical of an RF pulse.

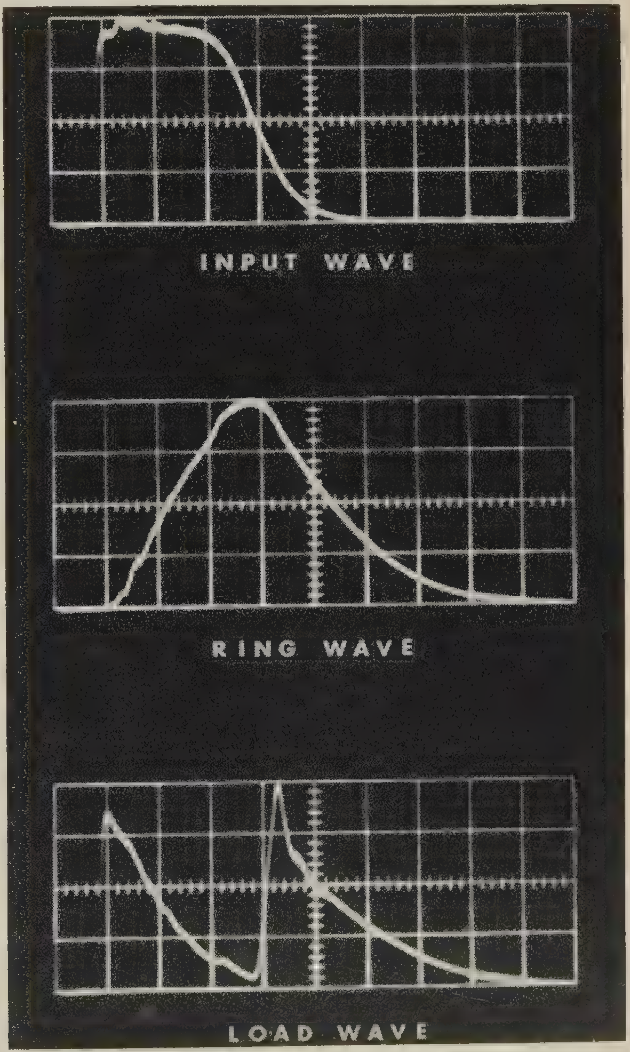


Figure 12 — Wave amplitudes at various points in the ring.

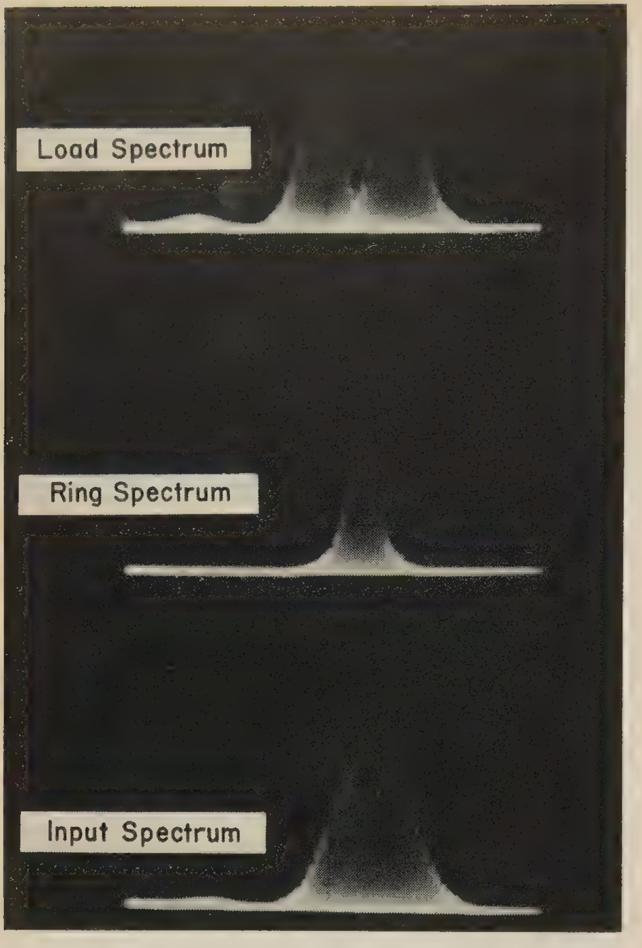


Figure 13 — Spectra at various points in the ring.

The ring forward wave spectrum is shaped by the Q of the ring. The load wave spectrum shows the energy which had been extracted by the ring. An indication of the Q is the fact that the pulse width of the driver was 6 μsec. The Q of the ring has been measured to be 6800 at critical coupling. This compares favorably with a calculated value of 7500.

The figures referred to above illustrate how the gain which can be obtained from a ring driven by a short pulse driver can be considerably less than that obtained from a long pulse or CW driver. The gain, of course, depends upon the relationship between the Q of the ring and the bandwidth of the driver spectrum. The load wave spectrum has proved to be a most sensitive indication of ring tuning. For a fixed driver frequency, the horizontal position of the notch can be controlled by the length of the ring. The depth of the notch can be controlled by the coupling to the ring and can, in fact, be made to go through zero at critical coupling. In a qualitative way, it is seen that the sum of the ring forward and load spectra equals the input spectrum.

At this time, some mention might well be made of the measurement of power in the ring. It is evident in Figure 12 that the ring wave can differ greatly from a rectangular pulse. For this reason, one should not measure the average power in the ring and then use the driver duty cycle to find the peak power. The method found to give reproducible results is sketched in Figure 14. In this system, the ring wave is simultaneously displayed with a calibrating pulse from the signal generator. One may zero beat the two signals to remove any frequency sensitivity in the amplifier-detector as a factor. By payin careful attention to loss and coupling measurements an to calibration of the signal generator, it is believed tha peak power is determined within 1 db. It is also possibl to use a CW signal generator noting level shifts rathe than matching pulse heights.

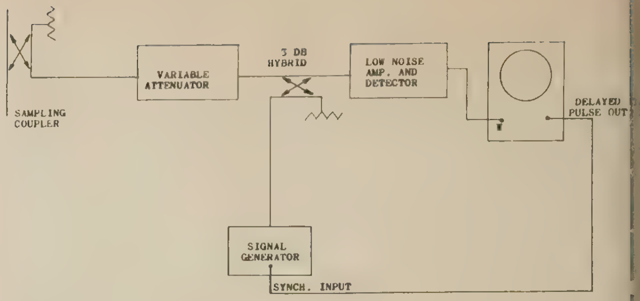
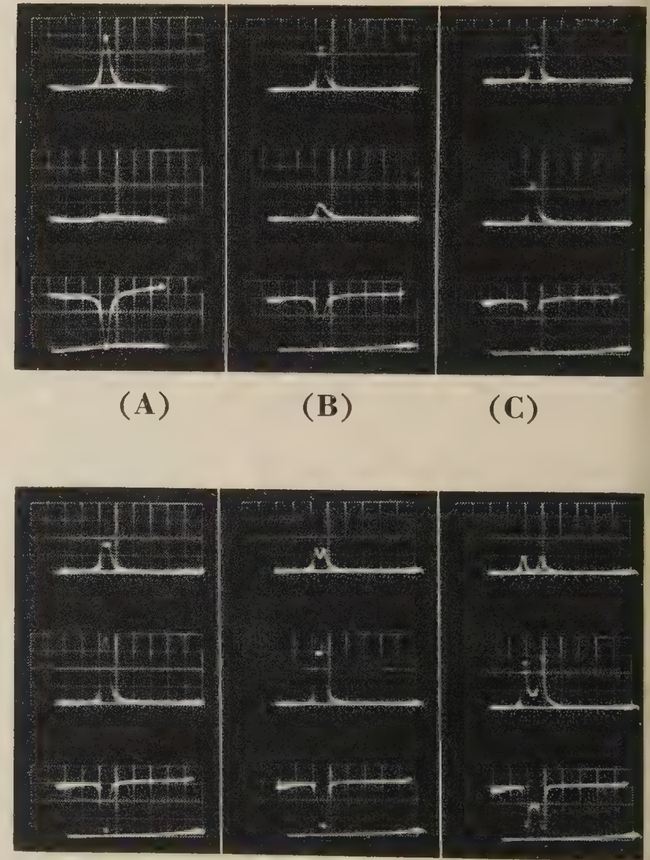


Figure 14 — Block diagram of peak power measurement circui

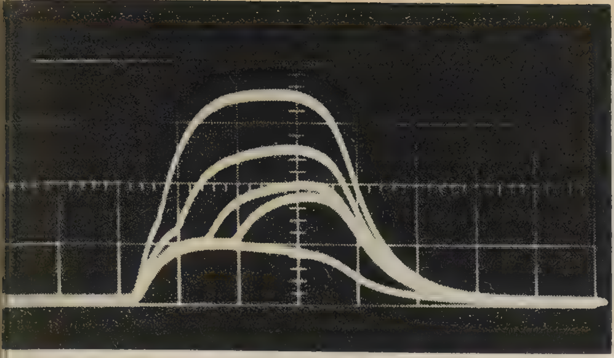
In Figure 15, the forward wave in the ring, the inpu reflected wave and the wave to the load are shown as a reflection in the ring is increased. The signal input was a swept signal, so the results are the same as a variation in ϕ in the analysis of the first part of this paper. It is see that the curves are identical in shape to those predicte



(A) (B) (C)

(D) (E) (F)

Figure 15 — Variation in ring forward, input and load waves as reflection within ring is increased. Input to ring corresponds to three squares deflection. Forward wave is attenuated by 16.5 db in each photograph. Reflected wave at input is attenuated by 10 db except in figures (E) and (F), where it is attenuated by 8 and 5.9 db respectively. The wave to the load is unattenuated.



ure 16 — Variation in firing time of TR tube with change in input level.

the theory. The variation in the attenuation required each picture should be noted. The variation was cessary to keep all the pictures on scale.

There are several observations which can be made ative to the testing of duplexer tube performance with e traveling wave resonator. The problem of measuring loss has already been discussed in section one, where e dependence of the measured loss upon the reflection efficient in the ring was illustrated. The measurement recovery time is also worthy of some discussion. It is vious that any wave introduced into the ring at or ar a resonant frequency of the ring will be multiplied. is also true that after the main pulse, a duplexer tube ll introduce a time varying loss in the ring. Thus, one measuring the magnitude of a simulated echo signal ich is dependent not only upon the characteristics of duplexer tube but also upon the tube's interaction th the ring. Experience has shown that variations of order of magnitude of the recovery time of a broad-nd tube can be obtained as the simulated echo signal is ried in frequency.

Another point worthy of mention is that the maximum in which can be obtained when measuring a duplexer be may not be determined by the arc loss of the tube t rather the level at which the tube ionizes and the operties of the particular ring. This can be explained the following manner. When an un-ionized tube is in e ring, the ring has a much different complex transmission coefficient than when the tube is ionized. If, when the tube is not ionized, the ring is completely mistuned, then there must be enough power coupled into the ring to ionize the tube and bring the ring into a resonant condition. Since this is a repetitive process on every pulse, there is a minimum value of C which can be used and therefore a maximum limit on the gain. The other situation which can exist is that the ring is tuned in both conditions but with a much lower gain and Q with the tube un-ionized compared to that with the tube ionized. If this situation exists, a high ultimate gain can occur although the initial gain will be low. The occurrence of events is that the ring forward wave builds up with an exponential rise determined by the relatively low Q of the ring and un-ionized tube until the level at which the tube ionizes is reached. At this point, the gain and Q are changed so that the ring wave starts to increase at a different exponential rate as determined by the new conditions. This sequence of events is illustrated in the superposed traces of Figure 16. These pictures were obtained by carefully adjusting the ring to be resonant with a duplexer tube in both the ionized and un-ionized states. The power level was then raised in very small increments from a point below to a point above that at which the tube would ionize on the coupled power. Thus at time t, the level will be greater for a larger input. The tube was made to fire at various times by carefully controlling the input power. The points at which the tube fires are obvious as are the changes in the charging rates which correspond to the change in Q.

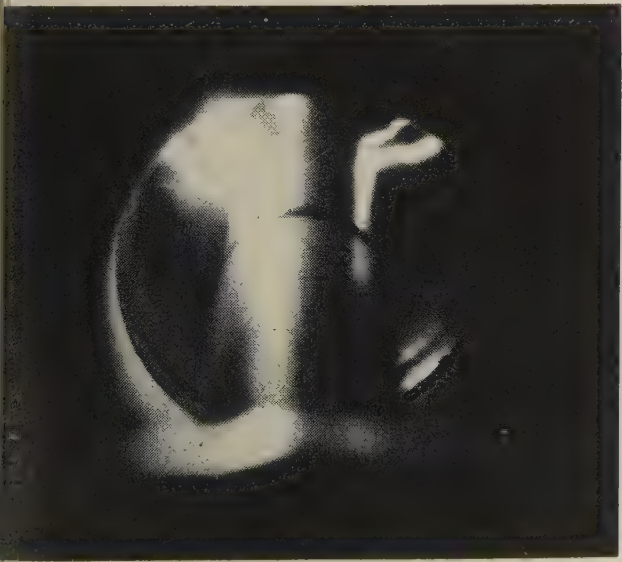


Figure 17 — Discharge in 3-1/8 coaxial line at 12 mw peak.

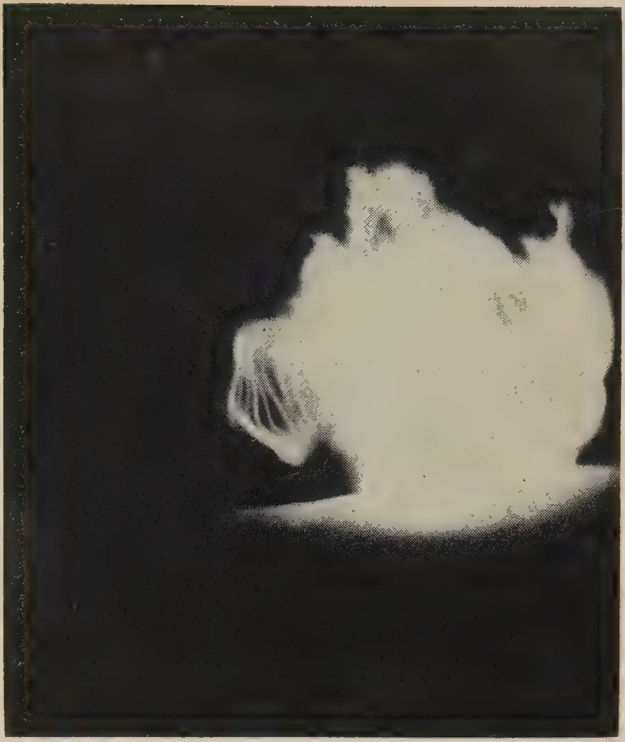


Figure 18 — Discharge in matching iris at 75 mw peak power.

Some of the more interesting and spectacular results which have been obtained can be listed as follows:

When 100 Mw peak power was simulated, this power level did not break down the waveguide by itself. When a slight mismatch was introduced, the results were, to say the least, pyrotechnically and acoustically spectacular. Figure 17 shows the discharge which resulted in 3-1/8″, 50 ohm coaxial line at 12 mw peak power. The onset of breakdown or occasional spitting occurred at 10 mw which correlates very well with theoretical computations which include frequency, pulse length, pressure, etc. considerations[7]. Figure 18 shows the discharge which obtained in a matching iris at 75 Mw. The open area the waveguide was 6 inches in height.

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CALCULATION OF MICROWAVE ANTENNA RADIATION SYSTEMS

By the Fourier Integral Method

L. CLAYTON, JR.
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troduction

In designing a microwave antenna the engineer is faced ith a set of criteria, among which are those that specify e desired radiation pattern of the antenna. Almost alays they will include the required gain, the polarization e two principal plane beamwidths, usually at the -3 db d -10 db contours, and the maximum side lobe level. ften the antenna has complex capabilities, such as sector anning or conical scanning, which involve changes in the ntenna configuration under which the design specificaons must be met. In addition the antenna may have to erform properly under a variety of environmental conitions and in spite of manufacturing tolerances.

Ideally, the designer would like to set his radiation patrn specifications into an equation and arrive at an annna configuration directly. Indeed, considerable effort has een directed toward this approach.[1] Generally, however, o little is known about the required radiation pattern to ermit this attack, and the problem is approached by the ial-and-error method in the large majority of cases. That , a reliable set of antenna conditions is assumed and the diation pattern is calculated, or a prototype is made and e radiation pattern is measured.

uygens' Principle and the Aperture Field Method

Any electromagnetic field and the sources of radiation re of course related by Maxwell's equations. However, s is all too well known, when these equations and eir necessary extensions are applied to the rigorous soluon of most practical antenna problems, the mathematics ecomes virtually unmanageable or uneconomically comlex. Rigorous calculation of the exact radiation fields of icrowave antennas is so time consuming and involved at exact solutions are generally obtained only for very mple cases. Fortunately, approximations can be made to the exact equations which can be solved fairly readily while providing solutions that are sufficiently accurate for many applications. We will describe certain approximations of this type and a method of solution.

Huygens' principle results from a mathematical extension of Maxwell's equations. It states that if a source of radiation is completely enclosed by an imaginary surface, and if the field is known at all points of the surface, the field at exterior points P can be determined by summing the contributions to the field at the exterior point from each elemental area of the surface, assuming each to be a secondary source of radiation.[2] This is illustrated in Figure 1, where the surface S completely surrounds the antenna at the origin.

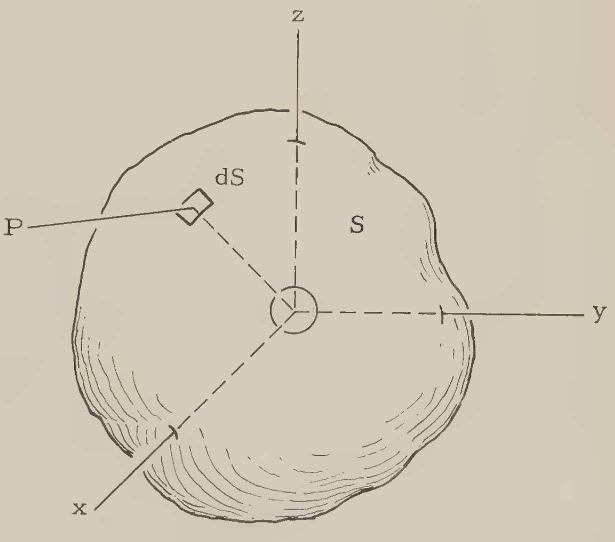


Figure 1 — Huygens' surface surrounding antenna.

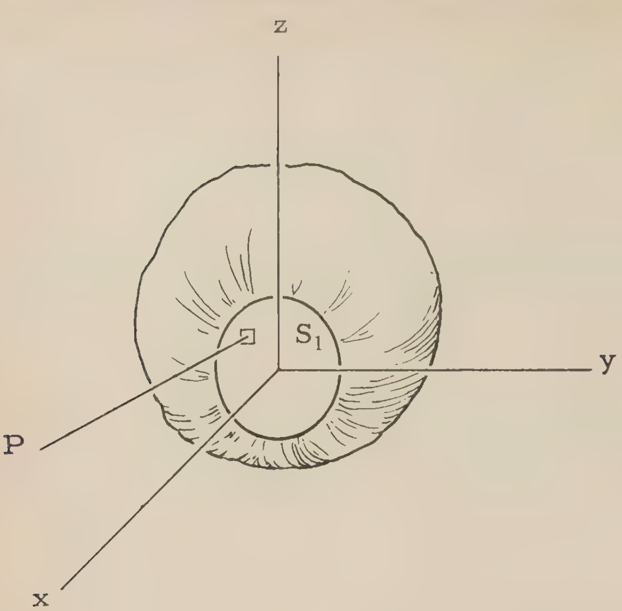


Figure 2 — Special case of Huygens' surface.

The summation is achieved by integration over S, taking into account the amplitudes, phases, and polarizations of the fields over S and the additional amplitude decays and phase shifts encountered between elements dS and points P by these elemental contributing fields. The complete radiation pattern is the field distribution over a sphere centered on the radiating antenna.

Huygens' principle is a powerful tool but a certain amount of specialization is required to make it useful. In the general case, it is no easier to calculate the field over S than it is to calculate the field at external points. However, if the antenna is like most narrow-beam, high gain antennas, almost all the energy is radiated through a relatively small portion of S, and for this case a special surface configuration can be employed which provides a solution. Since S can assume any arbitrary closed shape, let us shrink it down so that it is not much larger than the antenna.

Further, let us shape S as in Figure 2 so that the active portion of S is a plane surface. This plane surface is called the *aperture* of the antenna and is designated by S_1. Since we have postulated that nearly all the radiated energy passes through S_1, we can neglect the remainder of S without great error in determining the field at P.

Choosing the above special configuration for S results in two major improvements in our original situation as shown in Figure 1. First, the plane surface provides a convenient geometry for integration, and second, as we shall discuss below, it is relatively easy to obtain a close approximation to the field over S_1 by use of geometrical optics or by actual measurement.

Geometrical Optics Method of Calculating the Approximate Aperture Field

As indicated above, the value of the aperture field method is largely predicated on use of the geometrical optics approximation in determining the aperture field. Assuming that the antenna consists of a reflector and a primary feed, the field at a point in the aperture consists of the sum of the directly radiated field from the primary feed and the reradiated field of currents induced in the reflector surface by the radiated field of the primary fee

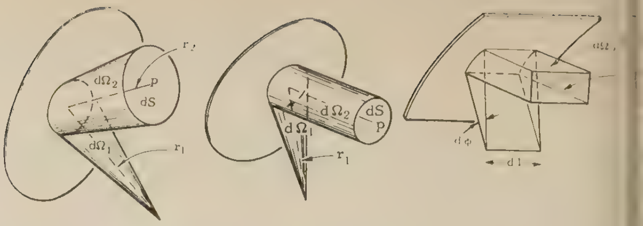


Figure 3 — Power flow by ray tracing a) general reflecting su face, b) paraboloid of reflection, c) parabolic cylinder.

The former can usually be neglected if the primary fe directs most of its energy onto the reflector. The r radiated field actually is caused by the sum of contributio of elemental currents over the entire reflector, addi vectorially. However, the resultant field at any particul point in the aperture is due predominantly to a certa portion of the reflector from which contributions arri with essentially the same phase. This portion of the r flector is called *the region of constant phase* for the pa ticular aperture point in question.[3] For relatively lo wavelengths the region of constant phase may cover vi tually the complete reflector for any point in the apertur As the frequency is increased the contributing region b comes smaller. At optical frequencies the region of co stant phase of a typical surface is extremely small, and the limit as the wavelength approaches zero the field at point in the aperture appears to be reflected from a sing point of the reflector. Lines which are normal to pha fronts of the propagated energy and joining the field poi the reflection point, and the feed are called *rays.*

In the geometrical optics method radiant energy is a sumed to propagate along such rays, which are straig lines in a homogeneous medium, and obey Fermat's law the optical path in any medium.[4] Further, rays exhib equal angles of incidence and reflection at reflecting su faces and obey Snell's[5] law of refraction at dielectric inte faces.

If a bundle of rays forming a cone such as $d\Omega_1$ of Figu 3a is assumed to represent a certain power flow, th reflected bundle of rays $d\Omega_2$ represents or "encloses" th same power flow, where each ray obeys the law of re flection at the surface. It can be seen that the field at point p, defined by the intersection of $d\Omega_2$, with the ape ture S, is

$$E_P = K\left[\frac{\Phi(\theta,\phi)d\Omega_1}{dS}\right]^{1/2} \qquad (1$$

where dS is the normal area subtended at the apertur by $d\Omega_2$ and $\Phi(\theta,\phi)$ is the radiation intensity due to th primary feed.

For the special case of a perfect two-dimensional co limator, such as the paraboloid of revolution or collima ing lens of revolution fed at the focal point, Ω_2 becomes cylinder (Figure 3b) and $dS = d\Omega_1 r_1^2$. For this case

$$E_P = K\frac{K[\Phi(\theta,\phi)]^{1/2}}{r_1} \qquad (2$$

For the one-dimensional collimator, such as the para bolic cylinder or collimating cylindrical lens fed by a lin ce on the focal line, $d\Omega_2$ becomes a cylinder of rec- ular cross section (Figure 3c) and

$$E_P = K\left[\frac{\psi(\phi)}{r_1}\right]^{1/2} \tag{3}$$

re $\psi(\phi)$ is the power flow per unit length of the re- or per radian of ϕ.

n these two cases E_p is easy to calculate. In the gen- case it is more difficult to determine the relation be- en dS and $d\Omega_1$. However, it turns out in a large ority of cases, even for defocusing that results in appre- le aperture phase error, that $d\Omega_2$ can be considered a nder and Equations 2 and 3 can be employed without t error in the calculated value of E_p. Silver[6] gives a hod of calculating the aperture field from the para- ric equations of the reflector surface. This method can employed for reflectors that are such poor collimators the above approximation causes excessive error.

trictly speaking, propagation by rays is valid only as wavelength approaches zero; however, it fortunately ns out that so long as the reflecting surface is both e and smooth compared with the wavelength, the field e to the surface is described quite closely by geometri- optics.

culation of the Radiation Field

n review, a special case of Huygens' principle has been d to obtain a plane aperture through which nearly of the energy radiated from the antenna passes. We find the scalar field over this aperture by ray tracing by measurement. Now we have the problem of de- mining the radiated field at a family of points P so t we can obtain a picture of the radiation pattern of antenna. Unless we make some restrictions on the sible locations of P, we are still faced with a formid- e problem, as shown by the complexity of the integral ich describes the scalar approximation of the field[7] at y point P in the front hemisphere of Figure 4:

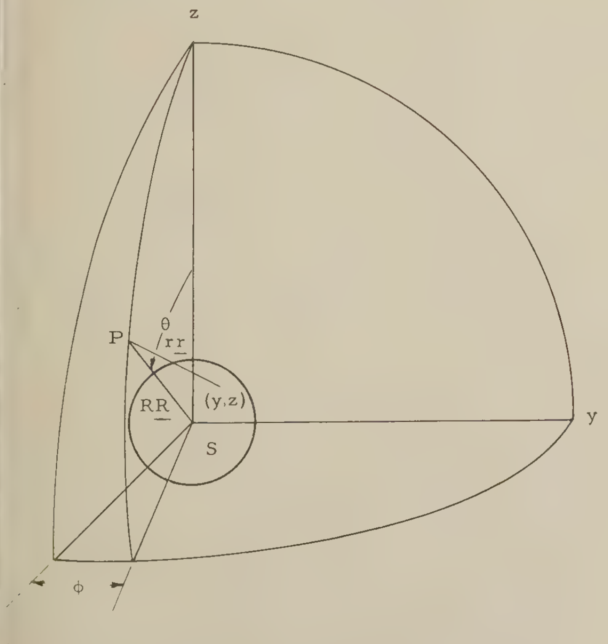


Figure 4 — Aperture and diffraction field geometry.

$$A = K_1 \int_S F(y,z)\frac{\epsilon^{-jkr}}{r}\left[\left(jk + \frac{1}{r}\right)x\cdot r + jk\,x\cdot p\right] dS \tag{4}$$

where

F (y,z) is a phasor, defined only in the y,z plane, which describes the field over S in amplitude and phase,
λ is the wavelength of the radiated energy.
k is $2\pi/\lambda$,
r,R,x, and p are unit vectors, the direction of p being the direction of power flow at the point (y,z) of the aperture, and
K_1 is a constant of proportionality.

Fortunately, in the usual situation we are interested in the radiated field at relatively large distances from the aperture, since there is generally a large separation between transmitting and receiving antennas, or between the antenna and target. Under these conditions Equation (4) can be simplified as follows without introducing appreciable error:

(1) The distance r, except in the phase term ϵ^{-jkr}, can be replaced by R, the distance from the field point to the origin (which should be located in or near the aperture).

(2) The term $1/r$ can be neglected in comparison with k.

(3) The directions of r and R with respect to the x-axis can be considered equal, permitting $x\cdot r$ to be replaced by $x\cdot R$.

Equation (4) then becomes

$$A = j\,\frac{K_1}{R}\int_S F(y,z)\,\epsilon^{-jkr}\,(x\cdot R + x\cdot p)\,dS \tag{5}$$

Since we are interested in the case where the radiation is confined to an angular region near the x-axis, the factor $(x\cdot R + x\cdot p)$ can be replaced by its maximum value 2*. The integral then becomes

$$A = j\,\frac{2K_1}{R}\int_S F(y,z)\,\epsilon^{-jkr}\,dS \tag{6}$$

It can be shown by expressing r in terms of R, Figure 5, and dropping terms of higher order than the first, that for large distances,

$$r \approx R - z\cos\theta - y\sin\phi \tag{7}$$

Substitution of Equation (7) into Equation (6) gives

$$A = K\int_S F(y,z)\,\epsilon^{jk(z\cos\theta + y\sin\phi)}\,dS \tag{8}$$

where $$K = j\,\frac{2K_1\epsilon^{-jkR}}{R}$$

** It should be noted that restricting the beam direction to lie on or near the x-axis does not exclude antennas that scan, since we can allow our coordinate system to shift with the beam axis while retaining the aperture in the y, z plane.*

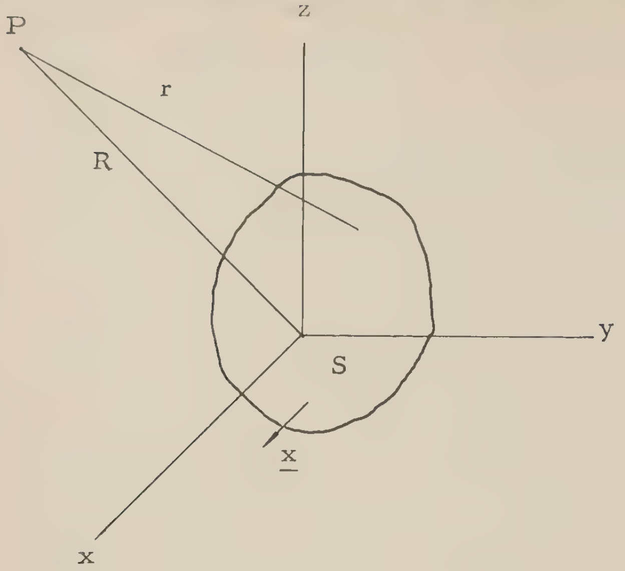


Figure 5

Although S can be arbitrary in shape, **F**(y,z) has been assumed to be zero everywhere except over S. We can define limits of integration for convenience either from $-\infty$ to ∞ along both axes or from $-a$ to a and $-b$ to b as in Figure 6, where the origin is centered in the aperture along both axes.

Since the order of integration is optional, Equation (8) obviously can now be written

$$A = K \int_{-a}^{a} \left[\int_{-b}^{b} F(y,z) \epsilon^{jkz \cos\theta} \, dz \right] \epsilon^{jky \sin\phi} \, dy \tag{9a}$$

or

$$A = K \int_{-b}^{b} \left[\int_{-a}^{a} F(y,z) \epsilon^{jky \sin\phi} \, dy \right] \epsilon^{jkz \cos\theta} \, dz. \tag{9b}$$

Both Equations (9a) and (9b) are of the form

$$A(u) = \int_{-\infty}^{\infty} f(x) \epsilon^{jux} \, dx \tag{10}$$

and are therefore *Fourier integrals.*[8]

Aperture Distributions

By making some reasonable restrictions on the possible positions of the field point P, we have reduced Equation (4) to the Fourier integral. This integral gives a close approximation to the radiation field from narrow-beam antennas at large distances from the aperture.

Let us define two types of aperture distributions that are found in common practice. The first type is that in which F is factorable (separable) into a product of two functions in y and z:

$$F = f(y) \, g(z) \tag{11}$$

This type distribution occurs in antennas that employ cylindrical reflectors or lenses fed with line source feeds.**

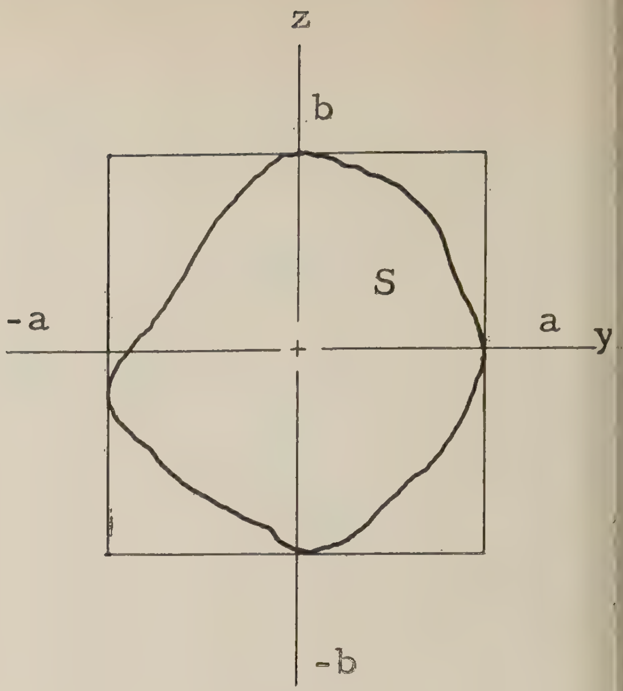


Figure 6

Here Equation (6) can be written

$$A = K \int_{-a}^{a} f(y) \epsilon^{jky \sin\phi} \, dy \int_{-b}^{d} g(z) \epsilon^{jkz \cos\theta} \, dz. \qquad (12$$

In this case, A is a product of two Fourier integra which can be solved separately for y and z.

The second type is the non-factorable type given b Equations (9a) and (9b). This type occurs with ci cular apertures, arbitrarily shaped apertures and with a most all apertures in actual practice.

For this type distribution the radiated field A c Equations (9a) or (9b) is not a product of two func tions of θ and ϕ as it is in Equation (12) for the fac torable aperture distribution. Two important subcase occur: (1) the case in which F(y,z) and therefore A are circularly symmetric about the x axis and (2) th general noncircularly symmetric case.

For the circularly symmetric case, referring to Equatio (9a), the integral within the brackets is solved wit $\theta = \pi/2$ for successive values of y. This determines th envelope of a function

$$f(y, \theta = \pi/2) = \int_{-b}^{b} F(y,z) \, dz, \qquad (13a$$

which we will call **f**(y). Equation (9a) may now b written

$$A = K \int_{-a}^{a} f(y) \epsilon^{jky \sin\phi} \, dy. \qquad (14$$

This is the Fourier integral which describes the solu tion of the two dimensional single slit diffraction prob lem. Therefore **f** (y) is referred to as the "equivalent slit" distribution of the field over the aperture S. The functior A describes the radiation field in any plane passing through the x axis.

** *Such distributions are likely to be factorable only in theoretical calculations; in practice phase errors caused by manufacturing tolerances generally cause the distribution to revert to the non-factorable type.*

r the noncircularly symmetric case, the total field can xplored in ϕ along successive cuts of constant θ ure 4) using Equation (9a), or in θ along successive of constant ϕ using Equation (9b). With reference quation (9a), the integral within the brackets is d with $\theta = \theta_n$ for successive values of y to de- ine the envelope of a function

$$f(y,\theta_n) = \int_{-b}^{b} F(y,z)\epsilon^{jkz\cos\theta_n dz} \qquad (13b)$$

use in place of f(y) in Equation (14). Figure 8 is tch showing how a radiation field can be presented by a succession of ϕ cuts at constant θ. The absolute nitude A is shown in rectangular form versus d ϕ. Obviously the same pattern can also be pre- ed as a succession of θ cuts. An "egg crate" type resentation, using both θ and ϕ cuts, provides a more led picture of the radiation pattern, and, in addition, s as a check on the accuracy of the computations.

efore proceeding to the next section let us define two bles,

$$u = ka \quad \sin\phi, \text{ and} \qquad (15)$$

$$v = kb \quad \cos\theta \qquad (16)$$

tting $y' = y/a$, $z' = z/b$ and dropping constants of rtionality, we can now rewrite Equation (9)

$$A(u,v) = \int_{-1}^{1} f(y',\theta_n)\epsilon^{juy'}\, dy' \qquad (17a)$$

re $f\,'(z,\phi_n) \approx \int_{-1}^{1} F(y',z')\epsilon^{jvz}\, dz'$

$$A(u,v) \approx \int_{-1}^{1} f(z',\phi_n)\epsilon^{jvz'}\, dz' \qquad (17b)$$

re $f(z',\phi_n) = \int_{-1}^{1} F(y',z')\epsilon^{juy}\, dy'$

Fourier Integral Computer

We have seen in the previous sections that the trans- nation between an aperture distribution of a narrow- m antenna and the far-zone radiation pattern can be ressed as a Fourier integral. Analytically, the integral still quite difficult to evaluate for most forms of the mination function. In this section we describe a spe- analog computer which provides graphical solutions he Fourier integral. This instrument, the Fourier In- ral Computer, is shown in Figure 8.

The computer automatically evaluates A(u,v) from ations of the form of (17) and records the absolute gnitude of A on an antenna pattern recorder, generat- a succession of cuts in u or v. Such a family of re- dings defines the spatial radiation pattern in the man- shown in Figure 7. For the general case of the two- ensional aperture with non-separable illumination ction, the computer is also used in carrying out the liminary reduction to an equivalent slit.

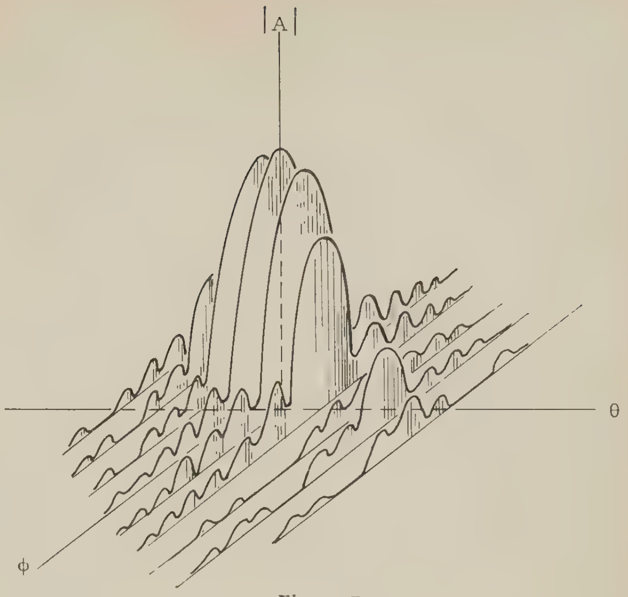


Figure 7

The Fourier integrals A (u,v), $f(y',\theta_n)$, and $f(z',\phi_n)$ are identical in form. To simplify the computer language and to provide flexibility in application, it is convenient to write the general integral in terms of a machine variable X and a machine parameter U:

$$I(U) = \int_{-1}^{1} F(X)\epsilon^{jUX}\, dX \qquad (18a)$$

or

$$I(U) = \int_{-1}^{1} F(X)\epsilon^{j[\psi(X) + UX]}\, dX \qquad (18b)$$

where we have written $F(X) = F(X)\epsilon^{j\psi(X)}$

The simplified block diagram in Figure 9 shows how this integral is evaluated by the CF 1 computer. The amplitude function F(X) and the phase function $\psi(X)$ are drawn in pencil or ink on a special dual graph paper. The curves are clipped to the drum of a graph-reading function generator with the X-axis parallel to the drum axis. As the drum rotates at 3600 rpm, two synchronized photoelectric heads scan the curves along the X-axis. In every drum revolution, passage

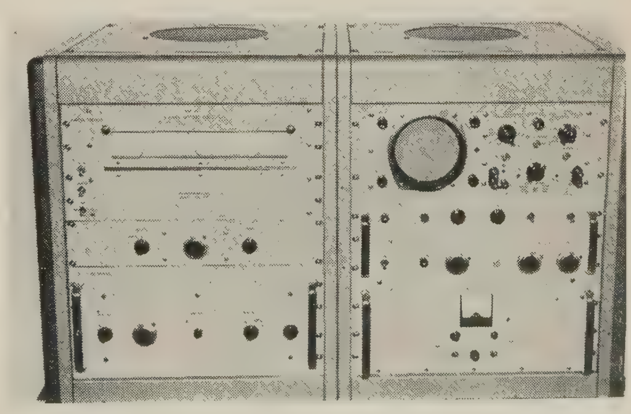
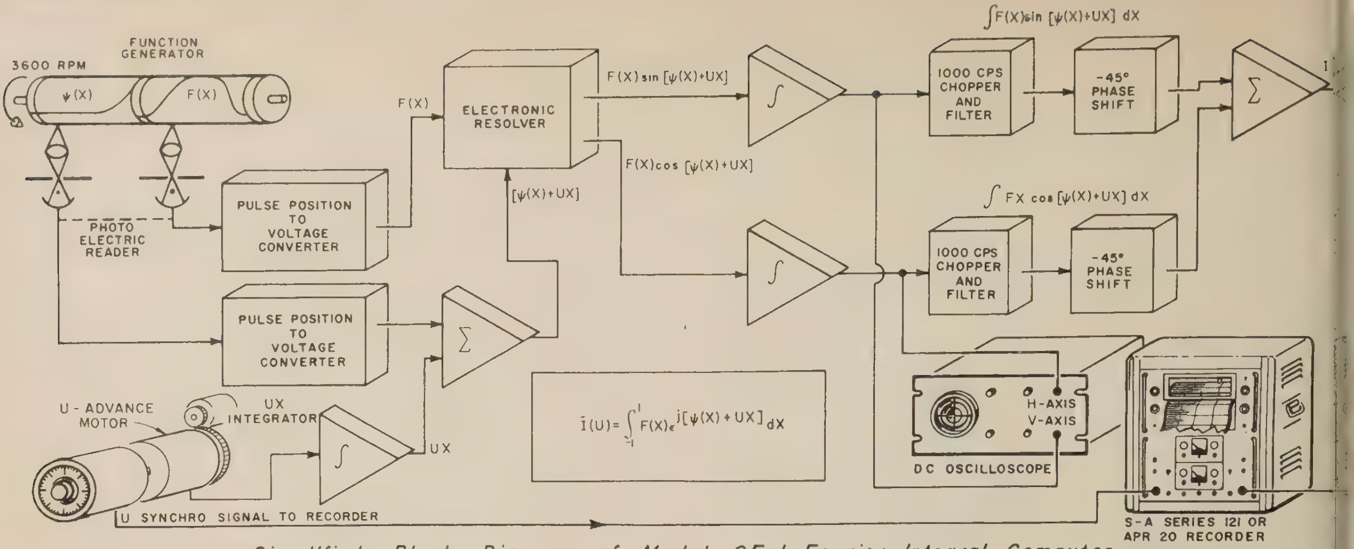


Figure 8



3600 RPM
FUNCTION GENERATOR
ψ(X)
F(X)
PHOTO ELECTRIC READER
PULSE POSITION TO VOLTAGE CONVERTER
PULSE POSITION TO VOLTAGE CONVERTER
F(X)
ELECTRONIC RESOLVER
[ψ(X)+UX]
Σ
F(X) sin [ψ(X)+UX]
F(X)cos [ψ(X)+UX]
∫
∫
∫F(X)sin [ψ(X)+UX] dX
∫ FX cos [ψ(X)+UX] dX
1000 CPS CHOPPER AND FILTER
1000 CPS CHOPPER AND FILTER
-45° PHASE SHIFT
-45° PHASE SHIFT
Σ
U - ADVANCE MOTOR
UX INTEGRATOR
∫
UX
Ī(U) = ∫₋₁¹ F(X)ϵ^{j[ψ(X)+UX]} dX
H-AXIS
V-AXIS
DC OSCILLOSCOPE
U SYNCHRO SIGNAL TO RECORDER
S-A SERIES 121 OR APR 20 RECORDER

Simplified Block Diagram of Model CF I Fourier Integral Computer

Figure 9

of each curve over its phototube generates a pulse whose time position is a measure of the function magnitude. Two pulse position-to-voltage converters generate varying direct voltages whose waveforms are reproductions of the amplitude and phase curves drawn on the graphs. A complete traverse of the X-axis is made in four seconds, so that each function is sampled at 240 points.

The phase argument of the integrand in (18b) is the sum of the phase function $\psi(X)$ and the product UX. A precision 10-turn helical potentiometer develops a voltage proportional to the parameter U, and this voltage is integrated to produce a linearly rising ramp whose instantaneous amplitude is proportional to UX. A summation circuit produces the total phase argument $\psi(X) + UX$. Geared to the U potentiometer is a synchro transmitter which controls the chart position of a Scientific-Atlanta Antenna Pattern Recorder, and a motor which automatically advances U after each four-second integration period.

An electronic resolver performs the conversion:

$$F(X)\epsilon^{j[\psi(X) + UX]} = F(X)\cos[\psi(X) + UX] + j\,F(X)\sin[\psi(X) + UX] \qquad (19)$$

The resolver is capable of operation through 30 revolutions of $\psi(X) + UX$. The two quadrature components of the integrand are fed to chopper-stabilized electronic integrators which evaluate the corresponding components of the integral between the X limits of —1 and 1. A complex-plane plot of the integral is displayed by means of a long persistence oscilloscope. This display provides a means of reading the phase of the solution and serves as a valuable tool in studying the generation of the pattern. Typical pictures of the oscilloscope trace, which we will call the Fraunhofer spiral*, are shown in Figures 11 and 12. After integration the quadrature signals are converted to 1 kc sinewave voltages and are added in phase quadrature to provide an output which is proportional to I(U).

Recording the solution, resetting the integrators, an advancing the parameter U are accomplished automatical during the retrace of the scanning heads of the functi generator. In addition, chopper-stabilized "memory" ci cuits automatically zero-set the function generators an resolver to eliminate the manual adjustments ordinari required in such analog devices. Each integration cyc establishes one point of the radiation pattern. Repetiti integration and U-advance generates a plane cut of 8 t 10 lobes in 15 to 25 minutes.

For conversion of a two-dimensional aperture to a equivalent slit, a single-cycle or non-repetitive mode operation is employed. Curves of the integrands $f(y,\theta_n)$ or $f(z,\phi_n)$ (Equations 17) for successive value of y or z are clipped to the drum of the computer an the corresponding values of the integral are read out, th amplitude from the recorder and the phase from th oscilloscope trace* *. The time required for conversion

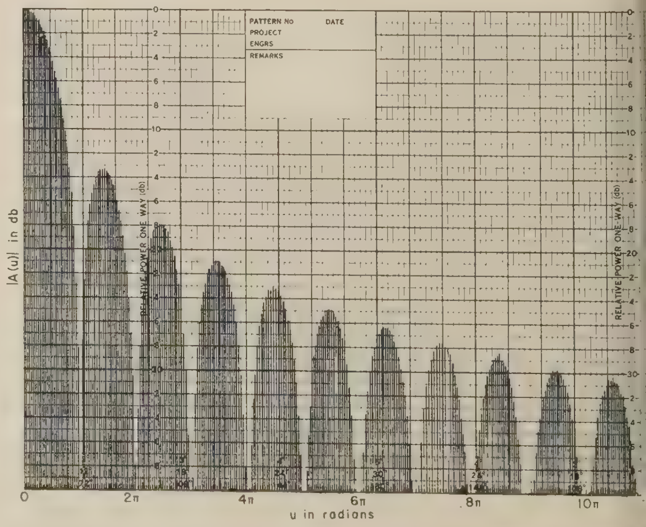


Figure 10

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* *From the "Far" or "Fraunhofer" zone. In optics the complex plane plot of the integral is usually called "the vibration curve."*

** *Although not provided in the basic Model CF 1 Computer a output voltage proportional to the phase of I(U) can be su plied, so that both phase and amplitude of the solution can b recorded.*

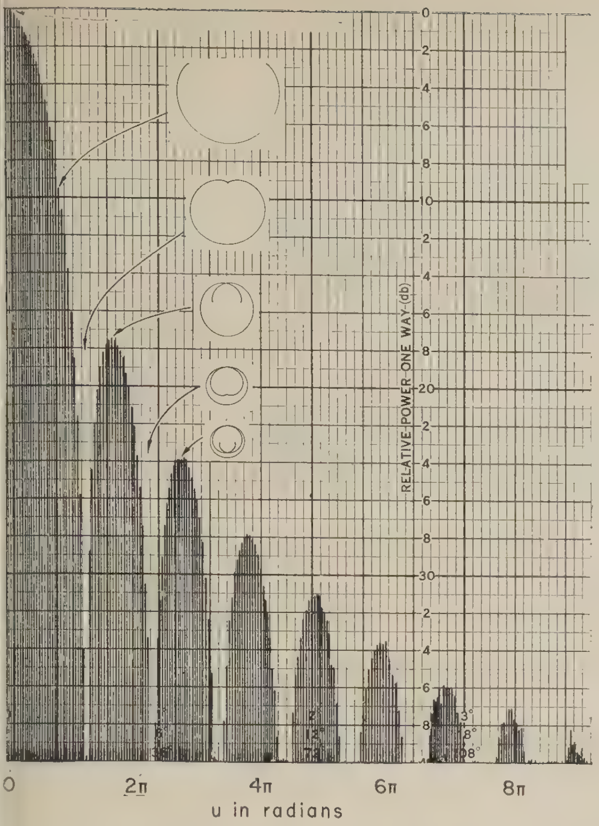

Figure 11

ne of the aperture to a point of the slit is between 30 onds and 1 minute including loading time of the drum d readout. Thus for most problems an adequate num-r of points can be obtained in about 20 minutes to rmit accurate construction of the equivalent slit illumin-on function graphs.

oblems

Figures 10 through 12 show the computed far-zone pat-rns for three illustrative problems. The first is that of e slit with constant field amplitude and phase along the t. This problem is described by the integral

$$A(u) = \frac{1}{2}\int_{-1}^{1} \epsilon^{juy'}\, dy' \qquad (20)$$

hose transform is

$$A(u) = \frac{\sin u}{u} \qquad (21)$$

The solution is used to calibrate the U-axis of the corder in degrees, from the known position of the roes of (sin u)/u and the definition of u given in quation (15). The pattern is shown plotted in db low the peak level for 10 lobes on one side of the ak. The solution is symmetrical about u = 0, and the mputer can calculate 30 lobes on either side of the peak.

The second problem is that of determining the xy-ane pattern of a y-axis slit with a semicircular am-itude distribution and constant phase. This problem is entical to the hypothetical one of a circular aperture with uniform amplitude and constant phase over the aperture. The solution is

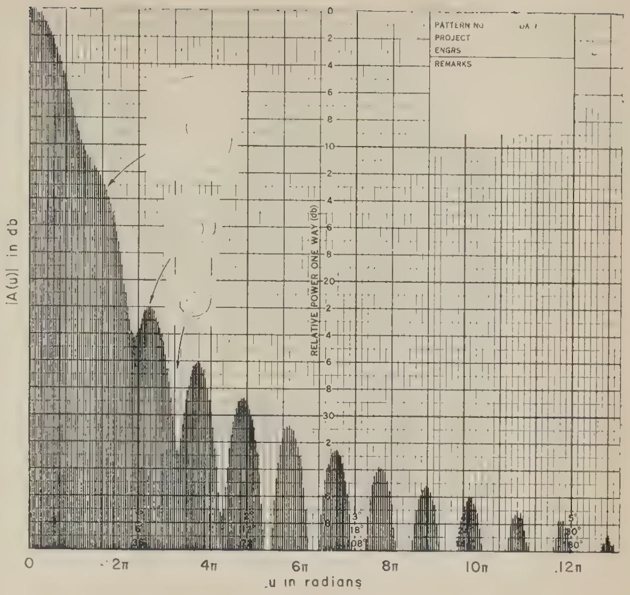

Figure 12

$$A(u) = \frac{J_1(u)}{u} \qquad (22)$$

again shown plotted in db.

The pattern in Figure 12 is that of a rectangular aperture with a cosine amplitude taper to -10 db at the edges and with a 90-degree quadratic phase error.

In addition to the patterns, oscilloscope traces of the complex-plane plot of the generating integral are shown for selected points of the pattern. The distance between the ends of each Fraunhofer spiral determines the amplitude of the far-zone pattern for the corresponding value of u. The angle between the horizontal axis and the line joining the tail of the trace to the tip gives the phase of the field, with respect to the phase of the contribution from the center of the aperture.

Summary

This paper describes some of the background leading to the Fourier integral method of calculating narrow beam radiation patterns. In addition, an analog computer is described which was specifically designed for automatic solution of the bounded complex Fourier integral. It is shown that the computer can be employed to obtain the solid radiation pattern from a plane aperture of arbitrary shape. Some typical patterns are shown to demonstrate types of solutions that can be expected. In addition to the solution, the computer provides an oscilloscope display of the complex plane trace of the integral. Photographs of typical traces are presented to show the correlation between the integral and the solution.

In addition to its use in the solution of antenna problems, the computer can be applied to other problems where the Fourier integral appears, such as in pulse spectrum analysis, real time networks synthesis, underwater sound, and optics. The computer is modular in design and the basic building blocks can be rearranged and extended to solve other problems involving integration of complex quantities.

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Correction

Two equation errors appearing in the paper "Analog Simulation: A Network Method for Solving Microwave Problems" (*the microwave journal,* June, 1960) have been called to our attention.

Equation 6a should read: $\mathrm{Re}(V_1) = \dfrac{\mathrm{Re}(I_1 V_1) + D_1 I_m (I_1 R_1)}{1 + D_1^2}$

Equation 11: The term on the right side of the equal sign should be:

$$\frac{1}{\propto}\ \frac{d}{dt}\ (Eymn)$$

DETECTION AND MEASUREMENT
Of Spurious Signals Generated By
MICROWAVE OSCILLATOR TUBES

R. E. BOOTH
R. G. VELTROP

SYLVANIA ELECTRIC PRODUCTS, INC.
MICROWAVE TUBE AND COMPONENT SECTION
Mountain View • California

roduction

ome voltage tunable oscillator tubes have been found produce a variety of coherent signals simultaneously. se can lead to a variety of associated problems de- ding upon the application of such a tube.

t is the purpose of this paper to discuss the detection, able identification and measurement of such signals.

n the application of a microwave oscillator, one as- ption often made is that all but an insignificant por- of the total coherent energy output is confined to a icular frequency or a small band of frequencies und that frequency. This assumption is justified for most the relatively narrow band, high Q, mechanically tuned rgy sources such as the klystrons commonly used for nal generators and mechanically tuned local oscillators in eivers. In the case of the more recently developed, wide ge, voltage tunable devices, this assumption may not be ified; and, if applied loosely may result in equipment ing inferior performance.

The signals present in the output of an oscillator, other n the Main Signal, have been labeled as "Spurious,' ame suggestive of their undesirability.

rminology

n dealing with spurious signals, experience has shown t the following definitions are convenient and unam- uous.

(a) Main Frequency, Main Output or Main Signal: the signal, originating in the tube, which has the highest power output for a given set of operating conditions.

(b) Spurious Signal, Spurious Output, Spurious Oscillation or Spurious Frequency: any coherent signal, other than the Main Frequency, which has been *definitely established as originating in the tube.* Harmonics of the Main Frequency are considered within this definition. Noise or noise bursts are not so considered.

(c) Extraneous Response, Extraneous Signal, or Extraneous Output: all other coherent signals which may appear on the detecting equipment which are neither the Main Frequency nor Spurious Signals. They may result from images, harmonic mixing phenomena in the detecting equipment, stray pickup, etc.

Spurious Oscillations

A detailed measurement of Spurious Signals generated by an S-band backward wave oscillator (BWO) was made in an attempt to identify Spurious Signals originating in the tube. This tube is voltage tunable over the frequency range from 2 to 4 kmc. An axial magnetic field is used for focusing, and the tube employs an interdigital slow-wave structure. The particular tube used as an example in this paper was chosen since it had a large number of Spurious Outputs of relatively high power level. It should be emphasized at this point that the majority of the tubes examined do not exhibit any detectable Spurious Signals with the exception of the second harmonic output. Some others may have Spurious Oscillations which are 30 or 40 db below the Main Signal level. The data on this tube are given to typify the characteristics of backward wave oscillators that do exhibit Spurious Outputs.

Spurious Oscillations near the Main Frequency might be caused either by an oscillation in a nearby mode with subsequent intermodulation with the Main Signal, or by a low frequency oscillation within the tube which frequency modulates the Main Signal. In either case, we would expect the pattern to appear as a series of discrete, evenly spaced signals having somewhat the character of an FM spectrum. Modulation frequencies between 20 and 200 mc have been observed in various types of backward wave oscillators when Spurious Signals were detected. Figures 1 and 2 show the measurements taken on one such tube which showed abnormally severe spurious behavior.

Tubes showing Spurious Oscillations can often be realigned in the magnetic field to keep Spurious Signals below a specific power level (usually determined by the sensitivity of the receiver it works into), but this realignment process usually reduces the power output across the band. The alignment for minimum spurious output is approximately the same as that for minimum noise output.

Receiver Responses

To illustrate the difficulties that Spurious Signals can create, consider the application of one of the tubes in

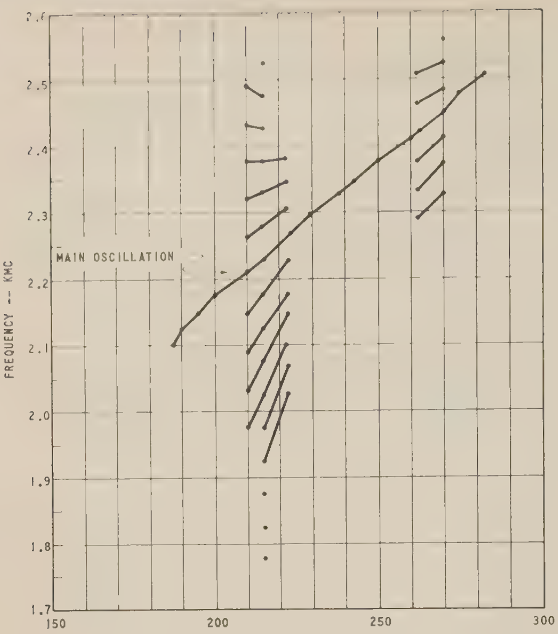


Figure 1 — Spurious output tuning characteristic.

question as a local oscillator in a wide range, high sensitivity, frequency search receiver with a panoramic display. If Spurious Signals are present, false responses can appear on the receiver display in two ways, depending upon the frequency relationship between the Main Signal and the Spurious Signal.

If the difference frequency between the Main and Spurious Signals (or a sufficiently strong harmonic of the difference frequency) falls within the band-pass of the IF amplifier, then the receiver will show a response without the presence of an incoming RF signal.

The characteristics of the response will depend upon how long the critical frequency relationship between Main and Spurious Signals is maintained as these frequencies are altered by the tuning voltage. Where the proper relationship is fleeting, the response will look as if an external signal is being received. On the other hand, if the Main and Spurious Signals tune together for a time, the response will be continuous while the relationship exists; and, if the Spurious Output is strong enough, the receiver can be effectively blocked during this interval.

When the frequency relationship is not that just described, Spurious Signals mix with incoming RF signals to produce false responses in addition to those provided by the Main Local Oscillator output. If, as in the usual panoramic display, the horizontal axis carries frequency information, then these responses will appear on the frequency axis as if they were true signals being received at frequencies equal to whatever Main Frequencies are associated with the offending Spurious Signals.

There are some clues which may help a little in recognizing this kind of false response. Assuming the Local Oscillator (LO) tube is being operated over its full tuning range, and there is RF preselection, two responses will occur with the desired response resulting from RF signal action with the Main Frequency being larger. The response due to the Main Signal and that due to the Spurious Signal will have several common characteristics since both are derived from the same RF signal. For example, pulse characteristics, fading characteristics and apparent geographical origin should be identical. Unfo tunately, some fairly sophisticated signal analysis equi ment is required to recognize the signal similarities ar accurately label the false response.

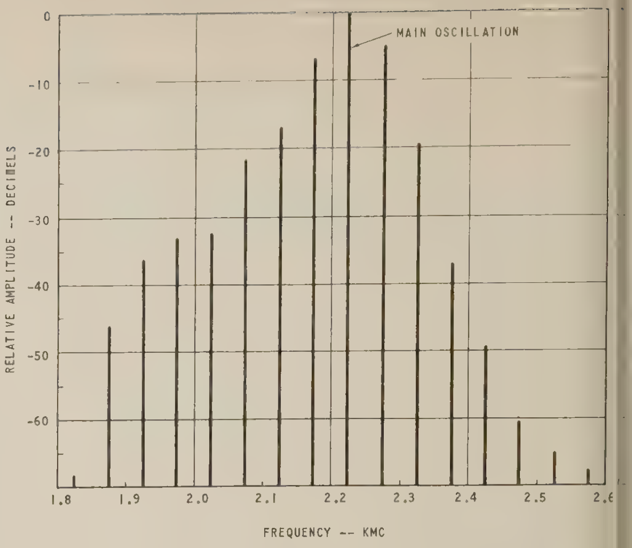


Figure 2 — Distribution of spurious signals.

Examination of Tubes for Spurious Output

A question often asked is whether a particular tul has Spurious Output. Clearly, an unqualified negati answer is improper since freedom from Spurious Signa is entirely a matter of degree. Where no Spurious Outpu are observed, the reporting of this fact, to be meaningfu must include a statement describing the sensitivity or mi imum detectable signal level of the measurement appar tus employed. Figure 3 is a block diagram showing th arrangement of the essential test equipment. It is suitab for most measurements.

Before attempting to obtain Spurious Output data, th receiver sensitivity should be carefully checked over th frequency range of interest. For broadband receivers, th sensitivity is likely to vary considerably. Also, the b havior of the receiver during warm-up should be note since sensitivity may vary until thermal equilibrium established.

Point-by-point Measurement Technique.

The block diagram of the equipment used to examin Spurious Outputs by the point - by - point technique shown in Figure 3.

The procedure followed in obtaining data on Spurio Signals is as follows:

1. Tune the tube and the receiver to a particular Mai Frequency. Adjust the receiver attenuator and gai controls to obtain a convenient response on th oscilloscope. Note the height.

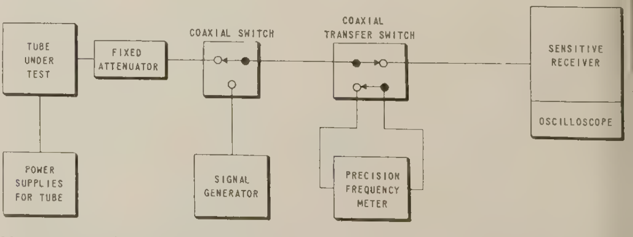


Figure 3 — Measurement of spurious signals from tubes; poin by-point technique.

Measure the Main Frequency with a frequency meter. The purpose of this is threefold:

a) If some part of the receiver system is saturated, the frequency meter tuning absorption will not be evident or will be greatly reduced.
b) Inaccuracies in receiver frequency calibration are eliminated.
c) The Main Frequency is accurately established for later use in distinguishing a true Spurious Signal from images and other Extraneous Responses appearing on the receiver oscilloscope.

The signal generator is switched in and tuned to the same frequency as that of the tube. The signal generator power is set for 1 mw into the output attenuator. The attenuator is adjusted to produce a response on the oscilloscope of the same height as in Step 1. The actual Main Frequency power output from the tube can be obtained in db below 1 milliwatt (—dbm) by algebraic addition of the signal generator attenuator reading to the value of the attenuator following the tube.

With the tube in the circuit and the receiver at maximum sensitivity, slowly tune the receiver over the frequency range to be searched. When a response appears on the scope it is necessary to stop and determine whether the response is an actual Spurious Output from the tube under test or an Extraneous Response caused by the receiver in conjunction with the Main Output or some other phenomenon.

Many of the observed responses can be rejected at once as not true Spurious Signals by observing the direction in which they move across the oscilloscope as the receiver is tuned. Those that move in the wrong direction as the receiver frequency is changed can be immediately eliminated as image phenomena in the receiver. The direction that true signals will move depends on the particular receiver employed and can be determined with the aid of the signal generator.

Other signals must be identified with the following procedure. Determine the frequency at which the frequency meter attenuates the signal under observation. If the signal is attenuated when the frequency meter is tuned to the tube's Main Frequency, then the signal is Extraneous. It probably is a result of mixing between Main Frequency and local oscillator harmonics generated in the receiver. In any event, the signal is *not* a Spurious Output and can be disregarded.

If, on the other hand, the signal is attenuated at approximately the frequency indicated by the receiver tuning dial, then the signal is almost certainly a Spurious Output from the tube.

If the signal is not affected when the frequency meter is tuned to either of the above frequencies, then the signal is Extraneous. In this case, it is possible that *harmonics* of the Main Frequency are mixing with the receiver local oscillator signal or its harmonics. Final verification of a Spurious Signal should be obtained by momentarily turning the tube off and noting that the signal disappears. If the signal does not disappear, then the receiver is probably picking up a signal radiated from some other source.

This step, the positive separation of true Spurious Signals from Extraneous Responses, is the most important step in the procedure. It depends almost entirely upon the judicious use of the frequency meter and is the reason for using a precision instrument.

5. Assuming a true Spurious Output from the tube has been identified, its power level may be determined by following Steps 1 through 3 for the Spurious Frequency. Subtraction of the signal generator attenuator reading for the Spurious Frequency from the reading for the Main Output will indicate the level of the Spurious Signal in db below the Main Output.
6. Continue the search for other Spurious Outputs through the frequency range of interest. After searching through the entire frequency range of interest, the recorded data will show all the Spurious Signals that are associated with the one particular Main Frequency.

The data obtained by using the above procedure are subject to one limitation. Since the search for the Spurious Signals is made for certain discrete Main Frequencies, the data will have a statistical characteristic, and the significance of the data will depend upon the number of Main Frequencies used.

A refinement in the point-by-point method is to substitute a Main Frequency rejection filter and an isolator for the attenuator in Figure 3. For typical local oscillator tubes having a minimum Main Signal power output of say +20 dbm, it is possible by this means to detect Spurious Signals as small as 110-115 db below the Main Signal.

Search Receiver Measurement Technique

Examples of the difficulties that Spurious Signals can create in a search receiver were given previously. These difficulties suggest a different procedure for detection of such signals which has no statistical limitation. This consists simply of employing the tube under test in the same environment as in its intended application — namely, as a swept local oscillator in a sensitive search receiver.

Figure 4 shows the components of such a receiver and the associated auxiliary apparatus. A portion of the local oscillator sweep voltage is applied to the oscilloscope to provide a horizontal coordinate which is a function of the local oscillator's Main Frequency. The signal generator simulates an incoming RF signal and its output must be essentially free from Spurious Signals.

The information resulting from this technique is somewhat different in form from that obtained from the point-by-point method. It is obtained in two ways:

1. Any signals appearing on the oscilloscope must result from a signal at the intermediate frequency coming from the mixer. If no RF signal is applied to the mixer, but a response appears on the oscilloscope, the tube under test has a Spurious Output separated from the Main Frequency by the IF.
2. Other Spurious Signals can be located by introducing a small, constant power RF signal into the mixer. The frequency of the RF is varied over the full tuning range of the local oscillator. If no responses appear on the oscilloscope (other than that caused by the Main Frequency), then the signal generator RF power output is increased by a small increment and the procedure repeated. This offers

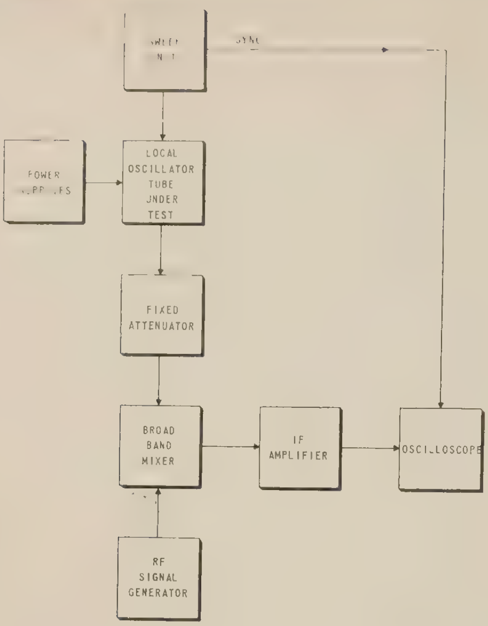


Figure 4 — Measurement of spurious signals from tubes; search receiver technique.

the advantage of locating larger Spurious Signals first and provides the following information about them:

(a) Relative size is indicated by the amount of RF power required to make the signal appear.

(b) The tuning range of the Spurious Frequency can be determined in conjunction with the tuning range of its associated Main Frequency. The horizontal position of the Spurious Signal on the oscilloscope relates it to its associated Main Frequency. The frequency of the Spurious Signal is determined from the frequency setting of the signal generator.

Figure 5 is an example of the Search Receiver presentation. The tube under test is being swept over a range of approximately 300 mc. Since the IF is 30 mc, responses of equal amplitude occur when the LO is 30 mc below and 30 mc above the signal generator frequency. These are the normal signal and image. As the signal generator is tuned across the band a third and smaller response appears and characteristically tunes along with the Main Signal for a short distance before it disappears again. The spurious image is not seen, in this case, since the tuning range of the Spurious Oscillation is less than 60 mc.

If it is desired to know the absolute power level of the Spurious Signals, one can now return to the point-by-point method with the advantage of knowing precisely where to look for them. The statistical feature is thereby eliminated from the point-by-point data.

The tuning relationship between Spurious Signals and the Main Frequency is of considerable importance in studies of the cause of the undesired signals. The search receiver technique provides a simple means of obtaining this relationship. The point-by-point method can also be used, but it is desirable, in this case, to employ two receivers — one each to monitor continuously the Main Signal and the Spurious Signal in question. This reduces the risk of "losing" the particular Spurious Signal under investigation.

Extraneous Signals

Mixing the harmonics of the local oscillator tube with

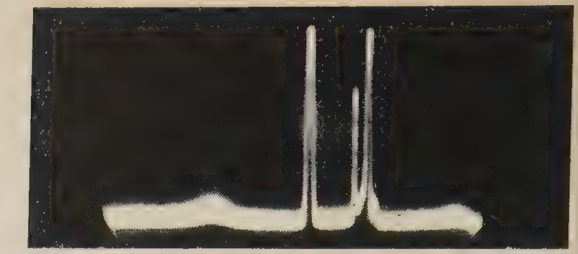


Figure 5 — Search receiver display.

the harmonics of the tube under test will produce Extra eous Signals. For instance, consider the case where t tube under test is oscillating at 2100 mc and its output fed into a receiver having a 160 mc IF. At the indicat frequency of 2100 mc, the local oscillator of the receiv oscillates 160 mc higher, in this case 2260 mc, produci an IF signal of 160 mc. An Extraneous Signal will observed at 2020 mc if the two second harmonics are sufficient strength. When the receiver indicates 2020 m its oscillator is operating at 2180 mc, and its second ha monic at 4360 mc, which mixes with the second harmon of the tube under test (4200 mc) to create a 160 mc signal.

Likewise, as the receiver is tuned, an Extraneous Sign may appear at 3070 mc. The oscillator in this case is o erating at 3230 mc and its second harmonic is at 6460 m This signal mixes with the third harmonic of the inp signal (6300 mc), again producing a 160 mc differen frequency.

To the casual observer, it would appear that when th tube is oscillating at 2100 mc, it also produces signals 2020 and 3070 mc.

To show the susceptibility of a laboratory receiver t harmonic mixing, signals were introduced by signal gen erators up to 21 kmc and the responses were observed o the receiver scope as the receiver was tuned over the 2 t 4 kmc band. Multitudinous Extraneous Signals were ob served and in some cases the receiver is almost as sensitiv to harmonic inputs as it is to the fundamental.

The actual second harmonic output is typically 40 d below the Main Signal for BWO tubes. Extraneous Signals resulting from harmonic mixing can be readily identified. If the signal appearing on the receiver scope cannot be dipped by an absorption frequency meter at th indicated frequency, it probably results from harmoni mixing. This can be confirmed by observing its rate o travel across the scope face as the receiver is tuned. I the signal results from a second harmonic of the oscillator, its rate of travel will be twice as fast as the Mai Signal, and proportionately greater for other harmonics

Elimination of Extraneous Signals resulting from harmonic mixing can be accomplished by better preselectivity in the receiver and by the use of bandpass filters in the output of the tube under test.

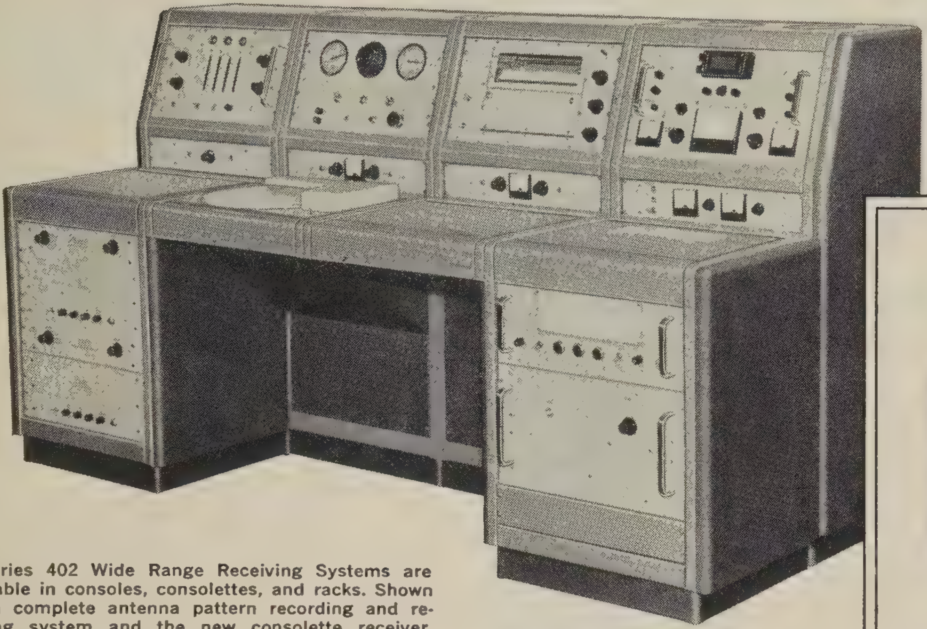
Conclusions

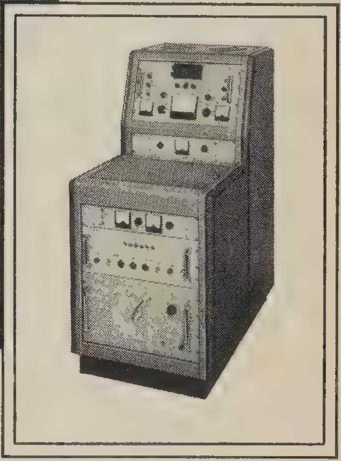
The difficulties created by Spurious and Extraneous Signals have been illustrated for the particular case of a panoramic search receiver. There are, of course, numerous other situations where Spurious or Extraneous Signals can be troublesome. The procedures given in this paper can be adapted to the detection and reliable identification of such signals, which is the first step in coping with them.

This work was supported by the U. S. Army Signal Corps under Contracts DA 36-039 SC-78281 and DA 36-039 SC-85402.

MAJORS and MINORS

. . . A Message to the Antenna Designer





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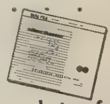

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Industry News

(Continued from Page 36)

HICKMAN PROMOTED AT AMPEREX

Mr. Frank Randall, president of Ar
perex Electronic Corp., Hicksville, N.Y
has announced the promotion of M
Wallace Hickman to head of Microwa
Tube Applications.

Mr. Hickman has been with Ampere
since 1954 in the Microwave Tube D
velopment group and the Microwa
Tube Applications group.

He will report to Mr. Selig Gertzi
chief applications engineer.

—*mwj*—

SYLVANIA APPOINTS DR. DANIEL H. GOODMAN

The appointment of Dr. Daniel
Goodman as manager of the Mountai
View Components Laboratory, a facilit
of the Special Tube Operations of Sy
vania Electric Products Inc., has bee
announced by Meyer Leifer, general mar
ager of the Special Tube Operations.

Mr. Goodman succeeds Dr. R. G.
Hutter who will direct activities of th
Special Tube Operations' Microwav
Physics Laboratory. Dr. Hutter will con
tinue as chief engineer for the Specia
Tube Operations responsible for engi
neering activities at both Mountain Viev
and Williamsport, Pa.

In his new capacity at the Com
ponents Laboratory, Dr. Goodman wil
be responsible for research, developmen
and prototype production of klystron
backward wave oscillators, travelin
wave tubes and special ferrite devices.

Since joining Sylvania in 1953, D
Goodman has been in charge of th
traveling-wave tube development pro
gram at the tube laboratory in Mountai
View. He previously spent six years wit
the Electronics Research Laboratory a
supervising engineer of the Microwav
the University of California and wa
Tube Group. From 1941 to 1945 h
served as a radar officer with the U.S
Navy.

Dr. Goodman received a PhD degre
in electrical engineering from the Uni
versity of California. He is a membe
of Sigma Xi, Eta Kappa Nu, Tau Bet
Pi, RESA and is a senior member of IRE

(Continued on Page 74)

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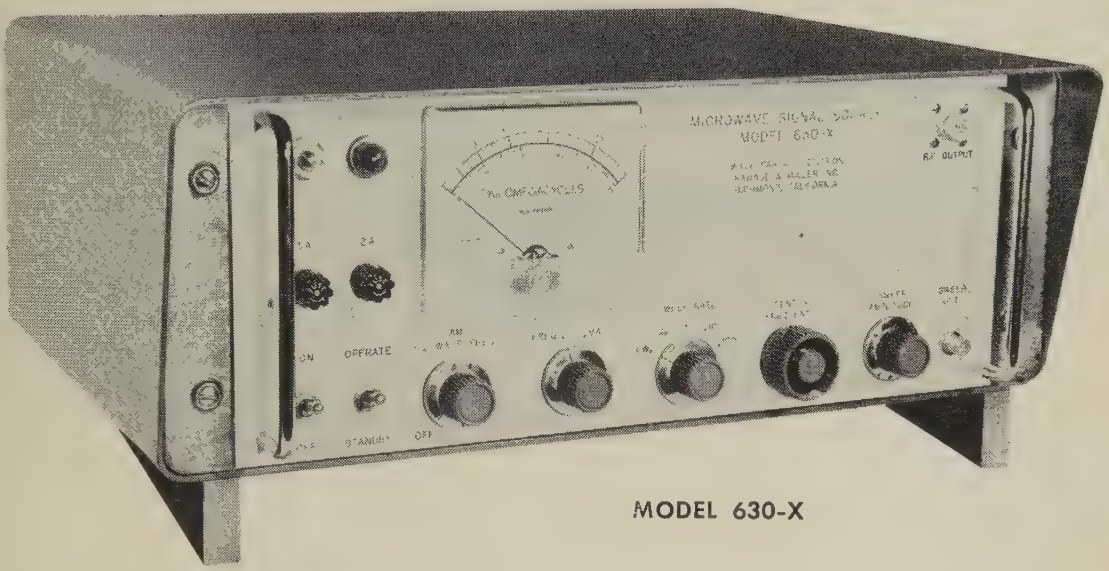

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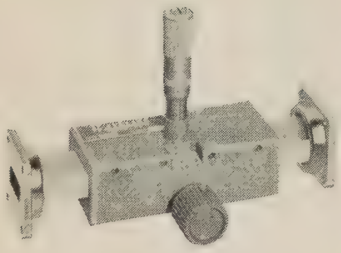

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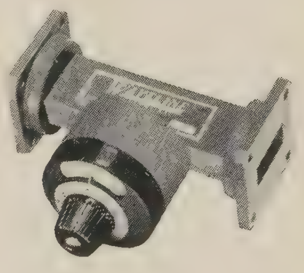

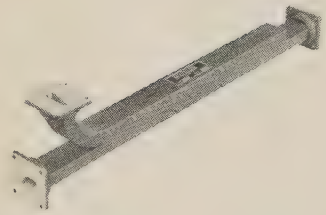

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(Continued from page 72)

CALIFORNIA MICROWAVE FIR EXPANDS

Guide Manufacturing Co., Sun Vall Calif., has launched a major expansion p gram, with emphasis in the microwave fie

Highlight of the expansion program the announcement of active, full-time parti pation in the management of the compa by its president, John J. Guarrera.

The management change at Guide brin Guarrera's two decades of microwave e perience directly to bear on the expand program of this company. Guarrera's e perience in this area dates back to 194 when he received his BSEE from M.I. Since that time, he has worked with seve leading developers of microwave, electron guidance and defense equipment. He hol or has contributed to more than a doz patents in the microwave field.

Guarrera was one of the original stoc holders in Guide when the firm was form in 1955. Recently, he acquired a controlli interest in the company and began supe vising its expansion into the areas of eng neering subcontracts and microwave deve opment. In the future, he will personal supervise research and engineering activiti for this firm. Edward B. Ryskowski conti ues as vice president and general manag of Guide. He will supervise manufacturi operations.

With Guarrera's active participation, was announced that Guide would market line of proprietary products for the fir time. All of the initial items are in th microwave field. They include: precision a tenuators, dummy loads, crystal holder bolometer mounts, mixers and direction couplers. The firm will also pursue subco tracts for the development and manufactu of custom designed and fabricated com ponents and assemblies.

—*mwj*—

SPERRY RAND EXPANDS

A plant expansion program addin 30,000 square feet of floor space to it Gainesville, Fla. facility, has been com pleted by Sperry Electronic Tube Divi sion of Sperry Rand Corp.

(Continued on page 76)

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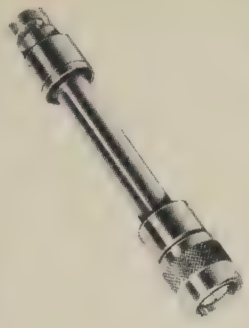
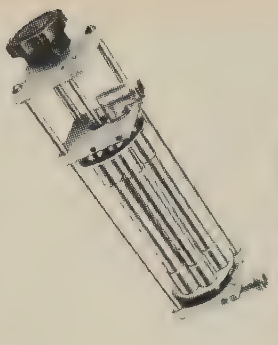
characteristics can be
ved.

LOW PASS LA, LB, LC SERIES
These low pass filters exhibit an extremely broad stop band with no spurious response at frequencies less than 6 times cut-off. The pass band attenuation and VSWR are very low with excellent cut-off characteristics. Available in medium and high power; miniaturized for airborne applications.



HIGH PASS HA, HC SERIES
These high pass filters provide low attenuation and VSWR over a broad pass band. The stop band attenuation rises sharply at cut-off and has no spurious responses. The HA series is available in medium power ranges. The HC is miniaturized for airborne applications.



TURRET LT SERIES
Six low pass filters are mounted around a central shaft and selectively engaged by a coaxial switch. Each filter has a cut-off frequency approximately 1.6 times the next lower frequency filter. The turrets provide a total bandwidth of over 10 to 1 in which any fundamental frequency can be filtered with a minimum of 20 db on the second harmonic and 60 db on any third through sixth harmonic.

GH & LOW PASS COAXIAL FILTERS FROM 100 TO 10,000 mc

Microlab manufactures a complete line of medium power, high power and miniaturized low pass filters; turret and continuously variable low pass filters; — medium power and niniaturized high pass filters. Units are available from stock for immediate delivery in the 5 standard Microlab connectors (Types N, BNC, TNC, C, HN) and in as many as 15 standard frequencies. Other frequencies and connector combinations are available for delivery within 2 weeks.

GENERAL SPECIFICATIONS

icrolab Series	LA	LB	LC	HC	HA	LV	LT
ut-off Frequency (F_C)	200-10,000 mc	200-2,000 mc	100-1,000 mc	100-1,000 mc	200-8,000 mc	200-4,000 mc	200-10,000 mc
ax. Pass Band VSWR	1.30	1.30	1.50	1.80	1.80		1.6
ax. Pass Band nsertion Loss	0.2 db	0.2 db	0.4 db	0.8 db	0.5 db	0.3 db	0.5 db
nsertion Loss (1)	25 db	25 db	15 db	21 db	28 db	20 db	
in. Stop Band nsertion Loss (2)	60 db	60 db	40 db	60 db	60 db	50 db	40 db
mpedance	50 ohms	50 ohms	50 ohms	50 ohms	50 ohms	50 ohms	50 ohms
ower Rating (Average)	10 watts	500 watts	10 watts	10 watts	50 watts	15 watts	10 watts
ower Rating (Peak)	4 kw	10 kw	1 kw	1 kw	2 kw	1 kw	2 kw
emperature Range	−55°C +150°C	−55°C +150°C	−55°C +150°C	−55°C +150°C	−55°C +150°C	−55°C +150°C	−55°C +150°C
nvironmental	Mil-E-5272	Mil-E-5272	Mil-E-5272	MIL-E-5272	Mil-E-5252		
inish	Silver Plate	Silver Plate	Silver Plate	Silver Plate	Silver Plate	Silver Plate	

Notes: (1) 1.2 Fc for low pass. 0.8 Fc for high pass (2) 1.5 to 6.0 Fc for low pass. Dc to 0.5 Fc for high pass

MICROLAB

570
W. Mt. Pleasant
Avenue
Livingston, N. J.
WYman 2-5700

Circle Reader Service Card 38

A NEW MICROWAVE GARNET

TRANS TECH INTRODUCES A NEW MICROWAVE GARNET

A much sought after polycrystalline garnet material has been developed at the research facilities of Trans Tech, Inc., Rockville, Md. The new garnet is the first of its kind with such a low dielectric loss at microwave frequencies. The special ceramic process was developed by Robert L. Huntt of the Trans Tech Research Department.

The first material to be released has an X-band dielectric loss tangent (Tan z — e″ / e′) of less than 0.0005. All other characteristics are similar to standard stoichiometric Yttrium Iron Garnet. The new material is type TT G-1600.

The improved garnet is available in bar form 1 inch x 1/2 inch x 6 inches having the following electronic properties: saturation magnetization 1600 gauss; Curie temperature, 264°C; dielectric constant, 15.3; gyromagnetic resonance line width, less than 50 oersteds and effective gyromagnetic ratio, 1.99.

The large dielectric constant, greater magnetic activity, narrow resonance line width and low dielectric loss of this material facilitates designing smaller components in the C and X band region having a higher merit figure than is possible with conventional ferrites.

Additional data on this product as well as other materials is available upon request.

Making News Again . . . continuously striving for better, newer microwave products through research. Since last month we have now advanced our testing of this new garnet into the S and C bands. All tests prove conclusively . . . Trans-Tech has done it again. For quality ferrites, garnets, polycrystalline and precision grinding . . . look to the double-T. Inquiry into this and other T-T products and services is invited.

TRANSTECH

foremost in ferrites

P. O. BOX 103 ROCKVILLE, MARYLAND

Represented Nationally by: J. E. Hachten Co., San Gabriel, California • Industrial Equipment, Inc., Washington, D. C. • P. J. Engineering Sales Co., Watertown, Mass. • Mr. Frank Hayes, 618 Syracuse Ave., Massapequa, N. Y. • Vanguard Associates, Inc., Melbourne, Florida and Atlanta, Georgia • Lloyd F. Murphy and Associates, Inc., Minneapolis, Minn.

Industry News

(Continued from page 74)

Opening of the addition brings the vision's total plant area to 160,000 squ feet. The Division now employs m than 600 people at Gainesville. The dition houses a complete tool room machine shop, as well as personnel related offices and a modern emplo cafeteria. It was designed to facilit future addition of another structure ho ing research and development and g eral administrative activities.

Sperry Electronic Tube Division n operates a multi-million dollar facil in Gainesville. Principal activities the manufacture, testing and sales traveling wave and klystron microwa tubes. The Division also carries on search and development work.

—mwj—

LORAL ACQUIRES HILLBURN

Loral Electronics Corp., New York, N. has acquired Hillburn Electronic Produ Co., of New York, it was announced Leon Alpert, Loral president and chairm of the board.

Bernard Gilman, president of Hillbu will continue as chief executive of the co pany which will be operated as a subsidia

Hillburn produces a broad line of elect mechanical relays for stepping, timing, p gramming, digital read-out and print-o applications in the field of electronics. relay designs are fully interchangeable wi distributor lines currently on the market.

Mr. Alpert termed the Hillburn acqui tion "another step forward in Loral's lon range plan to move into industrial a commercial areas compatible with diversifi operation." He indicated that definite pla for the expansion of Hillburn's marketi and distribution capabilities have alrea been formulated.

The Hillburn acquisition is the seco this year for Loral. In February, the co pany acquired the Alpha Wire Corp.

Loral is a prime producer of electron systems and equipment for the Departme of Defense and other government agencies

—mwj—

FINKE NAMED CORPORATE EXECUTIVE AT VARIAN ASSOCIATES

Herbert A. Finke has been named to th new corporate position of director of lon range product planning at Varian Assoc ates, Palo Alto, Cal., according to an a nouncement by Dr. E. L. Ginzton, chai man of the Board of Directors.

Finke, formerly vice president and ge eral manager of Polytechnic Research an Development Corp., will coordinat product objectives, plans and policies fo Varian's four operating divisions at th Palo Alto headquarters and for its fiv subsidiary companies. He will report di rectly to H. Myrl Stearns, president of th company.

As vice president and general manage of Polytechnic Research and Developmen Corp., he had full operating responsibilit

(Continued on page 78)

Circle Reader Service Card 39

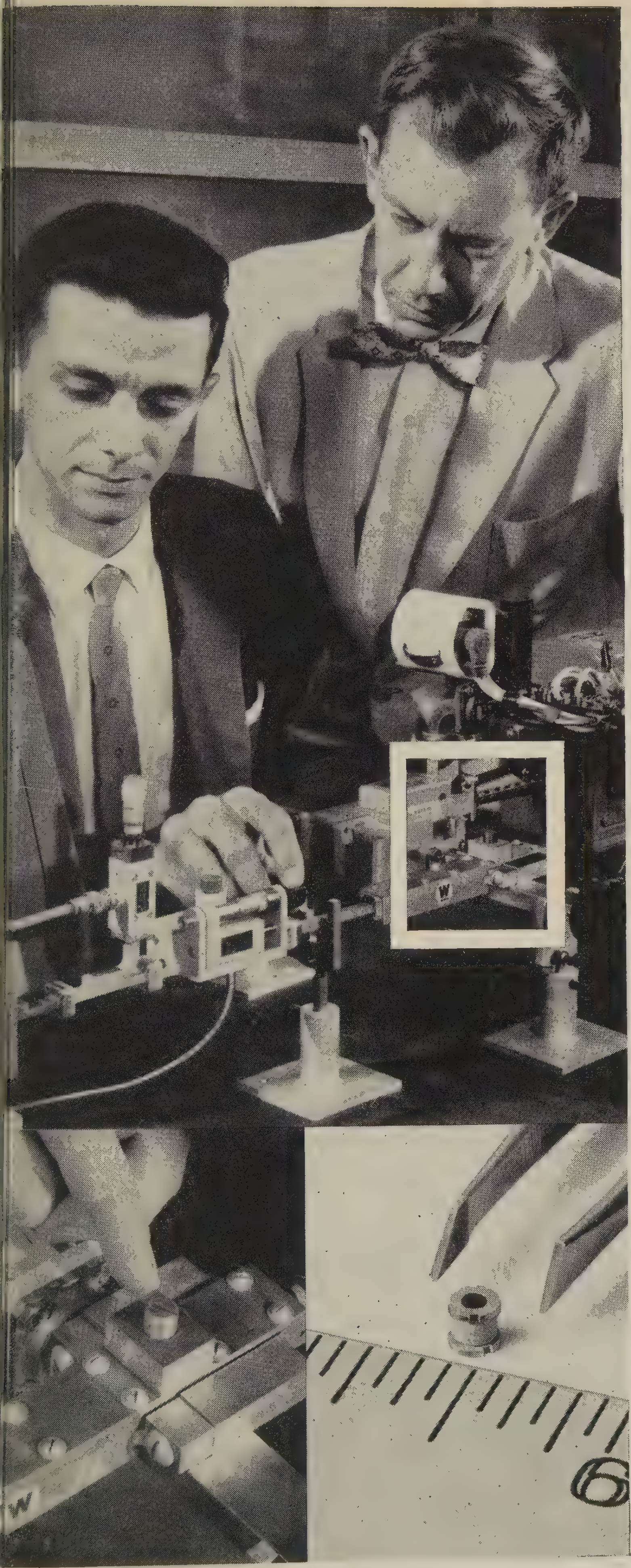


Photo: Courtesy Westinghouse Air Arm Division

Congratulations!

to WESTINGHOUSE for an exciting breakthrough.

A RADAR RECEIVER NOISE FIGURE of 2.8 db at an X-band operating frequency has been achieved by engineers of the Westinghouse Air Arm Division. Dr. Robert Rampolla (left), and Mr. Thomas Hollis (right), using a true non-degenerate X-band parametric amplifier and a Microwave Associates "pill" varactor (MA-4253), achieved a 20 db gain with excellent stability and ample bandwidth.

This remarkable accomplishment in low-noise amplification at X-band resulted from research on a program sponsored jointly by Westinghouse and the U. S. Navy.

Sophisticated Varactor technology at Microwave Associates which made these results possible has produced the most complete line available of advanced varactors in standard, miniature "pill", and glass packages.

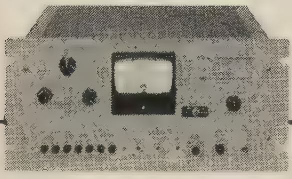
Write for detailed information and performance data on varactor techniques.

MICROWAVE ASSOCIATES, INC.

BURLINGTON, MASSACHUSETTS
Western Union FAX
TWX — Burlington, Mass. 942
Phone BRowning 2-3000

Circle Reader Service Card 40

New Versatility in Automatic Noise Figure Measurement



AIL's outstanding Type 74 Automatic Noise Figure Indicator is now available with continuously tunable (40 to 180 mc) I.F. Amplifier...or you can purchase the tunable IF Amplifier for modification of your present Type 74 equipment.

Check these high performance features:

- Noise Figure Range, RF or IF:
  0 to 36 db w/extension to infinity
- Accuracy (automatic operation):
  ±0.5 db (min); ±1 db (max)
- Input Frequency:
  30 and 40 to 180 mc (tunable); other frequencies available*
- Sensitivity:
  100 microvolts
- Bandwidth:
  2.0 mc
- Automatic or Manual Operation
- Recorder Outputs:
  Noise figure and AGC

Price **$830.00**
(Tunable Amplifier only) **$330.00**

The AIL Type 74 is designed to permit the adjustment of receiver parameters to minimize noise figure. No special training is required for use on the production line, in the laboratory, or in the field.

*For full information write:

AIRBORNE
INSTRUMENTS
LABORATORY
DEER PARK, LONG ISLAND, NEW YORK
A DIVISION
OF CUTLER-HAMMER, INC.

Circle Reader Service Card 41

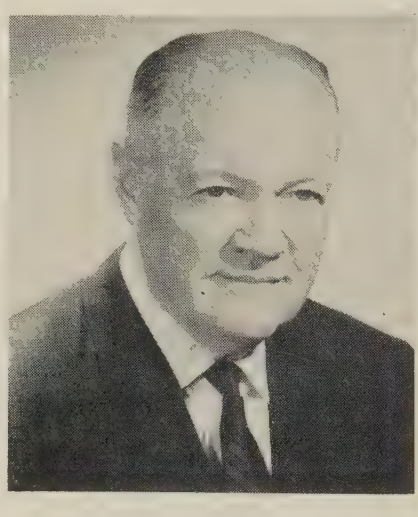
(Continued from page 76)

for the electronics firm which is a subsidiary of Harris-Intertype Corp., Cleveland, Ohio. He also served as a member of the Board of Directors of the subsidiary company.

Finke has served on a number of administrative committees of the IRE, and is a member of the executive committee of the Scientific Apparatus Manufacturers Association, the American Management Association, Phi Beta Kappa, and Sigma Xi.

—mwj—

MOTOROLA APPOINTS WATTERS ENGINEERING MANAGER



John E. "Soapy" Watters (Colonel, USA, Ret.) has been named engineering manager for Motorola's Western Military Electronics Center, Phoenix, Arizona, according to Joseph A. Chambers, vice president and general manager of the Company's Western Area Military Electronics operations.

In his new position, Watters is responsible for administrative matters pertaining to the 900 man Motorola engineering group engaged in the research and development of advanced military electronics equipment and weapons systems. He reports to the assistant general manager for Research & Development, Dr. Robert E. Samuelson.

Watters joins Motorola after a singularly successful Army career highlighted by service as chief of Technical Staff, director of Surveillance Department and deputy commander of the U.S. Army Signal Research and Development Laboratory (USARDL), Fort Monmouth, N.J.; and, chief of Combat Surveillance Department, U. S. Army Electronic Proving Ground, Fort Huachuca, Arizona. He is a graduate of the U. S. Military Academy at West Point, Class of 1933.

"Col. Watters' extensive experience in the planning, direction and operational usage of military electronics will contribute greatly to Motorola's understanding and evaluation of military requirements," Mr. Chambers said.

BAKER JOINS LITTON

Berkley J. Baker has joined the staff Litton Industries as advertising manag for the Electron Tube Division, San Ca los, Cal. Baker is filling a new positi created in the Tube Division's Marketi Department.

For the past 10 years Baker has be associated with Eitel-McCullough, In San Carlos, as advertising and public r lations manager. He is a 1950 gradua of San Jose State College.

Baker is a member of the IRE, publ relations chairman for the San Francisc Council of the Western Electronic Man facturers' Association, past public rel tions chairman of WESCON, a member the Association of Industrial Advertiser and a member of the American Manag ment Association.

He also is a member of the San Fra cisco Advertising Club and San Francisc Press Club.

—mwj—

GENERAL MICROWAVE CORPORATION ORGANIZED

General Microwave Corp., a new com pany with headquarters at Farmingdal N. Y., was launched in July, 1960 by tw former executives of PRD Electronics Inc.

The new firm is headed by Sherman A Rinkel, president and director of engineer ing. Moe Wind, formerly chief applica tions engineer and assistant sales manage at PRD is vice-president in charge o sales.

General Microwave is specializing i the design of microwave-electronic instru ments, systems components and special purpose test equipment. It is undertakin the research and development of 12 to 1 new products, distinctively different an new in the instrument field.

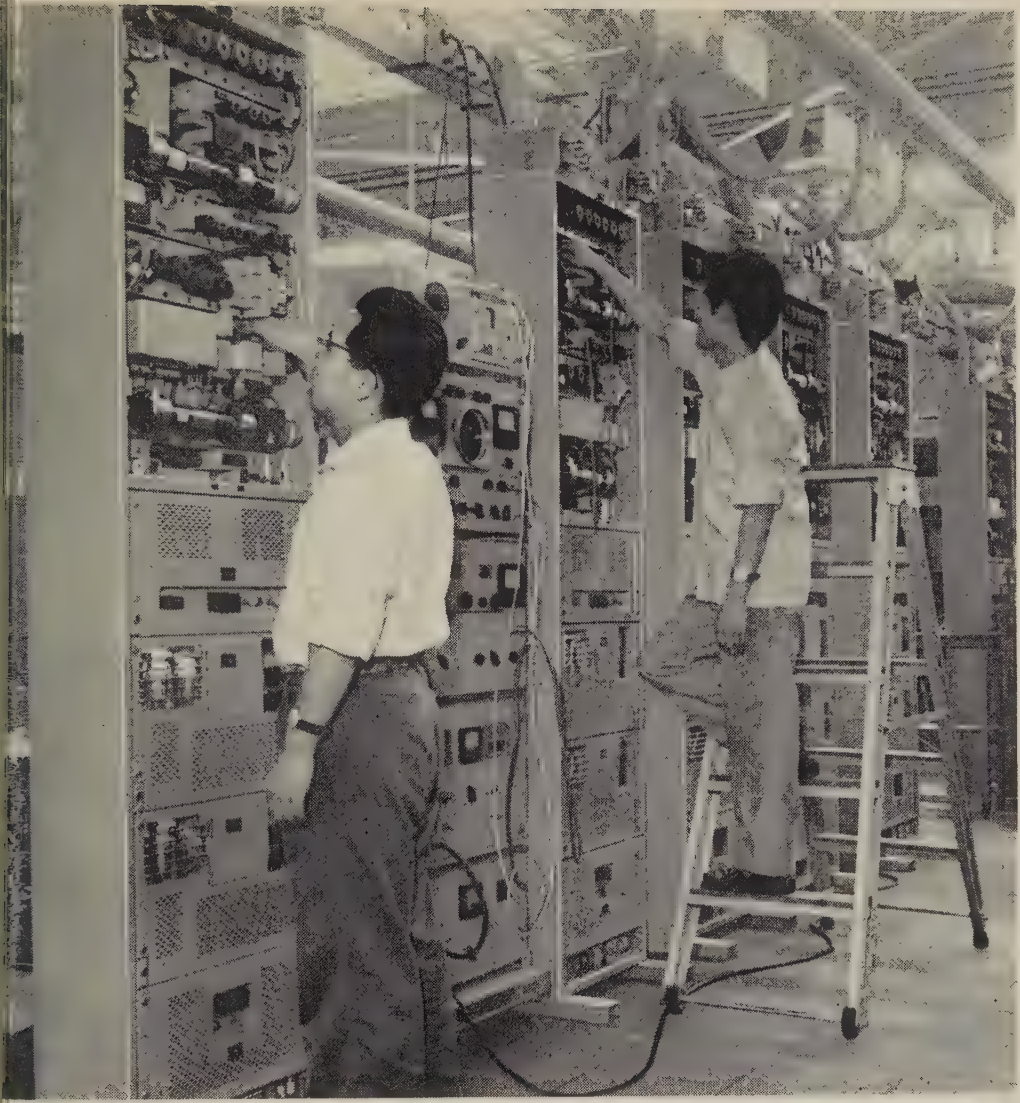
Messrs. Rinkel and Wind have extens ive backgrounds dating back to the earl forties in the microwave-electronics field As PRD's Chief Design Engineer, Rinkel had engineering cognizance of the bulk of PRD's catalog instrument and specia purpose system equipment activity ($6 million in 1959). Wind is known for hi contributions to the microwave measure ment field.

General Microwave is quartered in a modern 5000 square foot facility in the center of Long Island's electronic and aviation-missile industry.

Other personnel in the key engineering positions who have joined the company include William B. Sultan and Irwin Wietman, both formerly of PRD Electronics, Inc.

Plans call for expansion of both engineering and production groups to a 30-man operation within the year.

(Continued on page 80)



FINAL TEST of 6,000-mc transmitter-receivers at microwave assembly area of NEC factory

Microwave communications systems for 6,000-mc broadband multiplexing

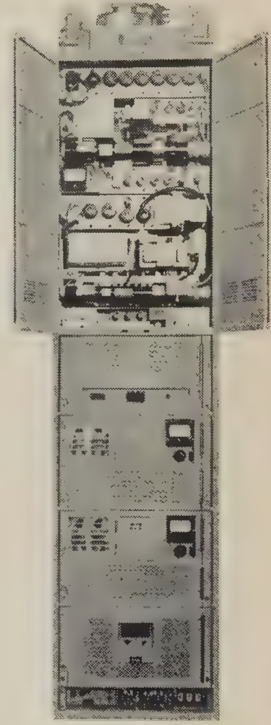
roadband, long-haul 6,000-mc relay systems are now being installed in Japan. hey are the first broadband equipment for commercial use in this band.

EC is offering this equipment in capacities of 960 and 1,200 telephone channels, nd superchannel equipment handling up to 2,400 channels becomes available oon. All meet CCIT requirements for toll-quality transmission.

gh stability and reliability are inherent in these features:

- Highly simplified schematic requiring less floor space than any similar equipment.
- Extremely high frequency stability by use of cavity frequency control, eliminating AFC
- Use of microwave diode for receiving frequency converter, improving noise figure

EC is the only source offering microwave communications systems in all bands rom 800 to 14,000 mc. Site engineers are prepared to recommend the most conomical system to PTT, military, and commercial users anywhere



Type 6G-1200 6,000-mc transmitter-receiver provides 1200 telephone channels or 1 color TV channel.

NEC *Nippon Electric Company Ltd.* Tokyo, Japan

Systems / Components

NO. 4 OF A SERIES

Our Customers' Laboratories Are Not Our Proving Ground

Recently we have had the pleasure of visting a standards laboratory to which we sold several of our dual channel insertion loss test sets a few years ago. With almost paternal pride, we checked over the equipment and studied the test log which recorded the thousands of measurements that had been made on this equipment as it was used eight hours a day, five days a week since the day it was delivered.

We talked with the people who use the equipment and when they told us that their maintenance costs were negligible, we were pleased, but not surprised. Not surprised, because we had heard the same story many times and for very good reasons.

Our equipment for insertion loss measurements was originally designed for our own use in calibrating our precision coaxial attenuators. We were forced to design it because we couldn't purchase equipment with the accuracy and precision we required.

These instruments were originally not built for sale, but for use as "tools" in our plant. Years later, at the request of our customers, we put them into production and have since sold about 400 sets. By this time, these instruments had made thousands of measurements in our plant and were as thoroughly tested and "de-bugged" as it is possible for an instrument to be. To reduce the time needed to train our employees to perform measurements, we had made numerous changes in design for greater simplicity in operation. Obviously then, we are never very surprised when a customer tells us that one of our single or dual channel insertion loss test sets has given him trouble-free service for a number of years.

We've learned from this experience. It is now a matter of policy with us not to offer an instrument for sale until we have used one or more for a long period of time in our own plant or laboratory. We've found it to be a good business practice to test our equipment ourselves rather than pass the burden on to our customers.

® WECO

Specialists in Precision Microwave Calibration Equipment

Weinschel Engineering
KENSINGTON, MARYLAND

Industry News

(Continued from page 78)

ANDERSON, SIMON NAMED TO BOARD OF FXR, INC.

Tore N. Anderson, executive vice president and general manager of FXR, Inc., Woodside, N. Y., manufacturer of microwave and associated equipment, and Stanley Simon, financial consultant, have been elected to FXR's board of directors.

Mr. Anderson, formerly vice president and director of engineering of Airtron, Inc., a division of Litton Industries, joined FXR early this year. He is chairman of the Waveguide Connector Standardization Committee of the Electronics Industry Association and a consultant to the Defense Department's advisory group of electron parts.

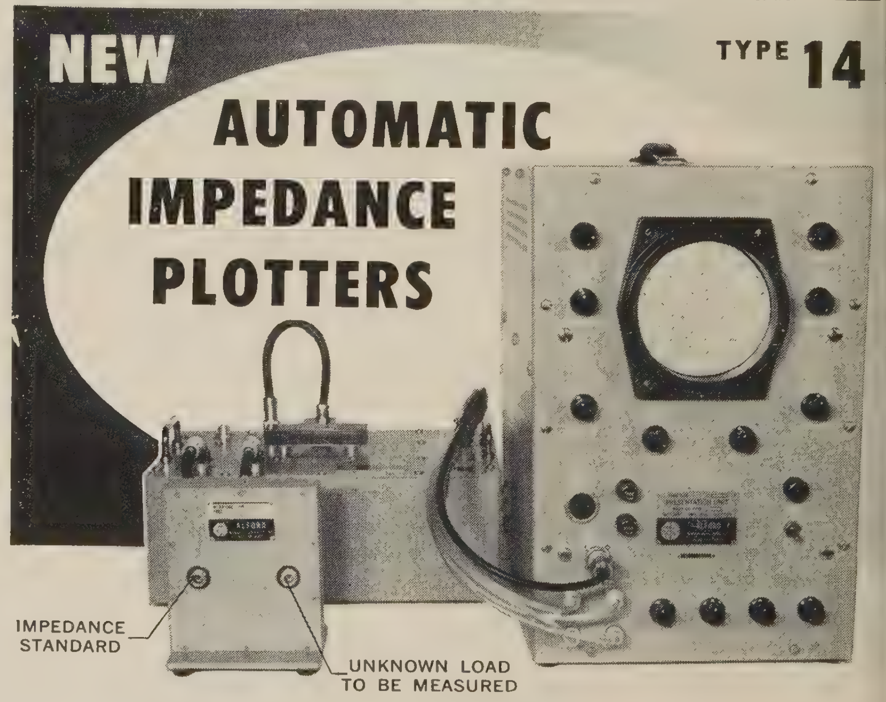
Mr. Simon, a senior partner in the firm of Stanley Simon and Associates, has been working with FXR for the past two years. He formerly was vice president and director of the Bulova Watch Co. He is a board member of the Kentucky Spindletop Research Center, a group engaged in the business and industrial development of Kentucky.

"The elevation of Mr. Anderson and Mr. Simon to the board of directors is in recognition of their leading roles in assisting in the continuing expansion of the company," Henry Feldmann, president of FXR, said.

MANSON LABS APPOINTS KRIEGER MARKETING MANAGE

Bernard Krieger has been appointe manager of marketing for Manson Labor tories, Inc., Stamford, Conn., develope and manufacturers of high power ele tronic test equipment and advanced com munications instruments.

Mr. Krieger formerly was marketin administrator for Budd-Lewyt Electronic Inc., of Long Island City, N. Y., and pric to that, a special projects manager o VT fuses at the Frankford Arsenal i Philadelphia.



- Presents effectively continuous impedance information over a frequency band.
- Entirely self-contained except for the use of an external oscillator.
- Models available to cover 2.5-250 mc, 30-400 mc and 180-1100 mc.

Write for complete information on AMCI Automatic Impedance Plotter

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ALFORD Manufacturing Company
299 ATLANTIC AVE. BOSTON, MASS.

SYMPOSIUM SEEKS PAPERS

he 1961 National Symposium of the fessional Group on Microwave Theory Techniques will take place on May 16, and 17 at the Sheraton Park Hotel Washington, D. C. The Technical Prom Committee for the Symposium is king original contributed papers in all ls of microwave research, development application, including especially, the owing areas: precision microwave surements — particularly involving smas, noise, parametric devices, etc.; d - state microwave devices, including ive devices, such as amplifiers and frency multipliers, and passive devices, h as switches and modulators; and rces and components at millimeter ves.

ive hundred word summaries of prosed papers should be submitted by cember 12, 1960, to Gustave Shapiro, airman, Technical Program Committee, gineering Electronics Section, National reau of Standards, Washington 25, C.

t is planned to publish an illustrated nposium program to be available for ribution to all registrants.

Authors of papers selected for presentan are invited to submit complete manupts for publication in a Symposium ue of the PGMTT Transactions.

—mwj—

NEW ELECTRONIC MATERIALS LABORATORY FORMED

A new electronic materials laboratory, lid State Materials Corp. located in edham Heights, Mass., has been med. The laboratory's experienced staff solid state specialists is headed by its esident, Mr. Joseph F. Wenckus, formy associated with the Ewen-Knight rp. Mr. Wenckus is well known in the terials field for his work in the growth single crystal semi-conductors, and as co-developer of the flame-spraying hnique for the preparation of ferrites d garnets while at Lincoln Laboratory, I.T.

Solid State Materials Corp. is engaged research, development and production single crystal intermetallic compounds, ped silicon and germanium, paramagtics such as doped sapphires, spinels d silicates and single crystal and lycrystalline ferrites and garnets. To ovide a complete materials service to e electronics industry, SSM also makes ailable a variety of furnace equipment hich it has developed specifically for ystal growth.

Solid State Materials Corp. is now owing single crystal aluminas, spinels, licates, cyanides and other special marials for maser applications. Gallium and dium arsenide crystals will be available ortly. A wide variety of specific materis utilizing virtually all known crystal owing techniques can be prepared in is versatile facility.

—mwj—

ANTLAB APPOINTS HOPKINS

It was announced by Antlab, Worthington, Ohio that Cliff Hopkins has been appointed sales manager for Antlab's New England Office, Burlington, Mass

Antlab manufactures antenna instrumentation, receiver systems and servo controlled antenna mounts.

Mr. Hopkins' responsibilities include coordinating technical services and sales operations in the expanding New England market. He will assist in product planning, advertising and sales promotion.

He is a graduate of Northeastern University and a member of the IRE.

Prior to joining Antlab, Mr. Hopkins was employed by George Gregory Associates of Natick, Mass. as a sales engineer.

—mwj—

E & M LABORATORIES FORMED

E & M Laboratories, a corporation recently formed in Van Nuys, Cal., is engaged in research, development, and production of ferrite components and microwave devices, according to an announcement made by Mr. Elliott Sprinz general manager.

Mr. Sprinz's background includes electronic systems and radar R & D for Systems Development Corp., Kearfott Co., Hughes Aircraft Co. and Rome Air Development Center. Mr. Harold Saltzman, appointed to head up the R & D, was more recently Research Laboratory manager for Kearfott Microwave Division and was formerly employed by Hughes Aircraft Co., Technicraft and G. E. Mr. Bob Gage, who is in charge of production engineering, has had extensive experience in the design and production of microwave components. He was formerly employed at Kearfott Co., The Martin Co., Century Electronics and Hughes Aircraft Co.

E & M Laboratories has a standard line of microwave isolators, waveguide switches, phase shifters, duplexers, electronic attenuators, and is engaged in performing specialized microwave R & D.

(Continued on page 105)

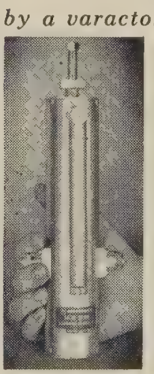
TO HIGH GAIN, LOW NOISE BENEFITS OF MOTOROLA PARAMETRIC AMPLIFIERS NOW ADD SMALLEST SIZE-WEIGHT CHARACTERISTICS AND LOWEST PUMP POWER REQUIREMENTS AVAILABLE

Take for example Motorola's range of exploration: Working amplifiers have been developed or are under development for operation from 10 mc to more than 10,000 mc.

Or consider size and weight: Negative resistance amplifier Type LPA01, tunable from 180 mc to 270 mc, is the smallest and lightest VHF parametric amplifier commercially available. It achieves 16 db gain over a 1.5 mc bandwidth with noise figure of 1.5 db.

In the UHF range, Type LPA02 is tunable from 400 mc to 460mc. This is a negative resistance type with a noise figure of approximately 2 db yielding 13 db gain and a 3 mc minimum bandwidth. Only 1.5 mw (maximum) of pump power is required.

Motorola designed laboratory units have been operated at S-band and X-band with high performance.



Motorola Type LPA01 parametric amplifier is a variable reactance amplifier of the negative resistance type. Two resonant coaxial lines are interconnected at the high impedance end by a varactor diode. One cavity is resonant at both the signal and pump frequencies, while the second cavity is resonant at the difference of these two frequencies. This use of dual resonance, which permits impedance matching at the pump frequency, is a significant factor in keeping pump power requirements to a minimum.

REPRESENTATIVE MOTOROLA SOLID STATE DEVICES

ISOLATORS • CIRCULATORS • PARAMETRIC AMPLIFIERS • SWITCHING CIRCULATORS • HIGH-SPEED, BROAD-BAND SWITCHES • PHASE SHIFTERS •

For detailed information, write:

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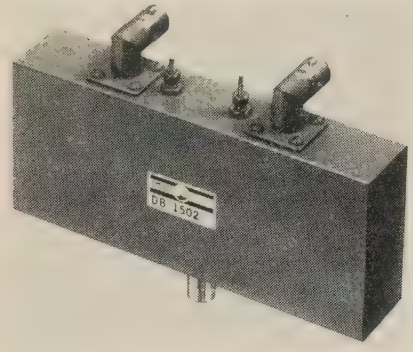
New Products

NEW TRANSFORMER ANNOUNCED BY DEMORNAY



DeMornay-Bonardi, Pasadena, Cal., announces a new IF transformer that can be used with all sizes of DB-665 balanced mixers. The unit is designed to match the push-pull output of a balanced mixer to the single-ended input of an IF amplifier.

The transformer insures efficient energy transfer and effective local oscillator noise suppression. The unit also permits the IF amplifier to be located remotely, independent of transmission line length effects.

Designated as the DB-1502 series, this transformer couples directly to the output jacks of the balanced mixer, sizes A thru E, and by cable to all other sizes. The output is matched to a 50-ohm coaxial transmission line. Two jacks with filtered connections to the crystal contacts are built in for external measurement of crystal current and local oscillator level setting.

Prices range from $138.00 to $154.00. Units are available from stock and literature will be sent on request.

Circle Reader Service Card 101

—mwj—

SYLVANIA ANNOUNCES HIGH-SPEED, HIGH-POWER MICROWAVE SWITCH

Development of a fast acting, high-power microwave switch that can be closed in tenths of a microsecond, was announced by Sylvania Electric Products Inc., New York, N. Y. at the International Congress on Microwave Tubes.

Dr. Rudolph G. E. Hutter, chief engineer for Sylvania's Special Tube Operations, made the disclosure in a technical paper entitled "Microwave Switching with Low Pressure Arc Discharges." The paper was co-authored by Dr. Robert Hill, inventor of the switch, and Steven Ichiki, both of Sylvania's Microwave Physics Laboratory in Mountain View, Cal.

Dr. Hutter said the new microwave switch uses a gas discharge, similar to that in a thyratron, to create a fast acting and relatively high power switch for a microwave line. In addition to closing in tenths of a microsecond, the switch can be reopened in a few microseconds.

Rapid switching, useful in transmitting and receiving microwave power, has special uses in radar systems, Dr. Hutter explained. The new switch is faster than present devices, including ferrites, which perform similar switching functions. Another advantage of the new switch is that there is no "spike" leakage of power usually found in transmit-receive tubes.

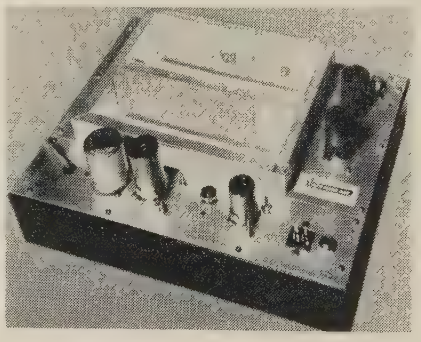
Circle Reader Service Card 102

—mwj—

NEW LINE OF CONVERTERS ANNOUNCED BY TAPETONE, INC.

Tapetone, Inc., Webster, Mass., announces the availability of a new line of high performance, crystal controlled converters for the 324 mc satellite tracking frequency. The WTC-324 is being used successfully to track the Transit 1-B Satellite by the Applied Physics Laboratory of the Johns Hopkins University and by the Ionosphere Research Laboratory of the Pennsylvania State University.

These converters feature a low-noise crystal diode mixer followed by a low-noise intermediate frequency preamplifier. This system provides the best over-all noise figure that is extremely stable and does not deteriorate with time.



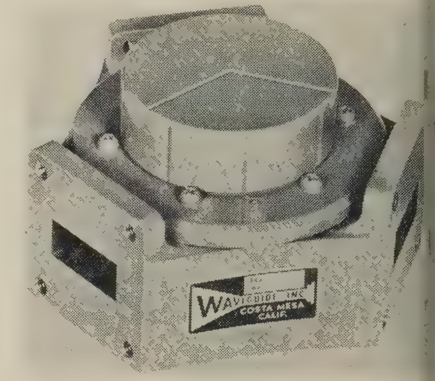
These converters also feature a double-tuned input cavity, which results in a high order of image rejection and spurious signal rejection. A crystal controlled multiplier chain furnishes the local oscillator injection to the crystal diode mixer. This technique also contributes to the high degree of stability. Standard output frequencies are 30 and 60 mc/s with 6.0 and 6.5 db over-all noise figures, respectively.

Additional available features are a crystal oven, various RF and IF bandwidths, and extra IF stages for more gain. Other input frequencies in the range of 300 to 550 mc/s and other frequencies from 20 to 60 mc/s are also available.

Circle Reader Service Card 103

—mwj—

X-BAND SWITCH FOR LABORATOR TESTING OFFERED BY WAVEGUID



Waveguide, Inc., Costa Mesa, Cal offers a new precision X-Band Switch th has been designed for the particular nee of laboratory testing.

Designated model WXS-120, the switc is a single pole, double throw, manuall operated unit with a frequency range c 8.2 to 12.4 kmc.

The advantages of the switch includ more convenient switching from a slotte line to a reflectometer and ready switchin from one signal source to an alternat source for gain measurements. The Waveguide X-Band Switch facilitates and als speeds tests while cutting down setu time.

The switch has low VSWR and hig isolation, which, combined with its compactness, make it especially adapted t critical laboratory requirements. The unused arm is terminated in a lossy materia allowing use of the switch between tw signal sources and a common line. Markings on the top of the knob show at glance which two arms are in use. Deten positioning is used to assure exact alignment on resettings. The size is 1-5/ inches height by 3-1/2 inches depth an the minimum mechanical life is 100,00 cycles. Price: $275 F.O.B. Costa Mesa Cal.

Additional information can be obtaine from the manufacturer.

Circle Reader Service Card 104

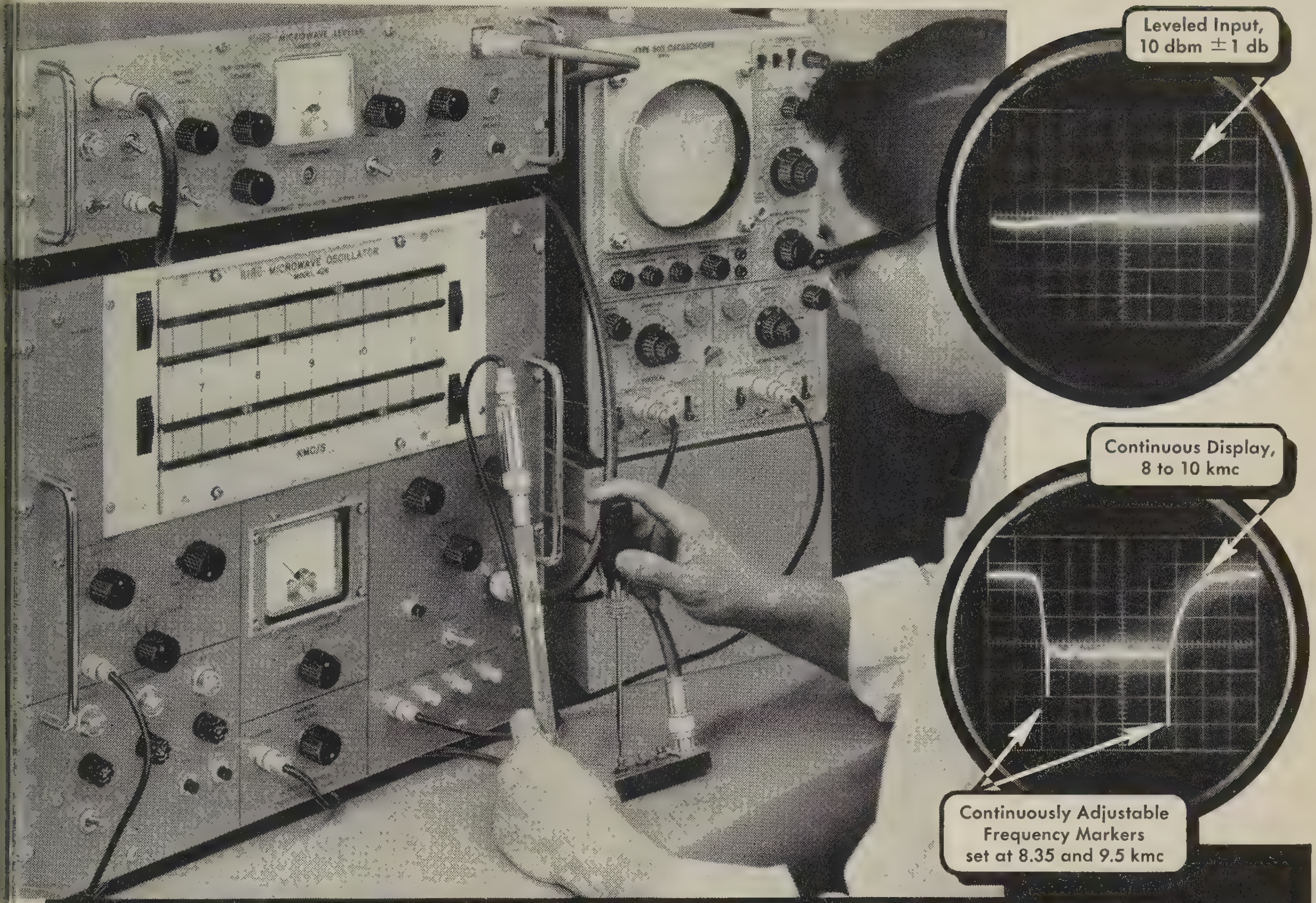
—mwj—

UHF POWER SIGNAL GENERATOR AVAILABLE FROM ROHDE & SCHWARZ

Development of a UHF power signal generator with exceptionally wide frequency range, from 275-2750 mc, maximum output power of 20 watts and high frequency and amplitude stability has been announced by Rohde & Schwarz, Munich, West Germany, manufacturers of electronic test and communications equipment.

(Continued on page 91)

ng insertion characteristics of X-band filter with Alfred Swept Generator. It consists of Alfred owave Oscillator and Alfred Microwave Leveler. This combination electronically sweeps frecy linearly with respect to time while maintaining RF power virtually constant across the band.


Leveled Input, 10 dbm ±1 db
Continuous Display, 8 to 10 kmc
Continuously Adjustable Frequency Markers set at 8.35 and 9.5 kmc

Save Test Time, Assure Test Accuracy

with ALFRED'S new SWEPT Microwave Generator..........

The scope patterns tell the story. Top pattern shows constant power input from Alfred Swept Generator to component (filter) under test. With known input, variation in output is due to filter characteristics. Lower pattern is especially significant, showing continuous, flicker-free display, 8 to 10 kmc. Any changes in stubs or irises are immediately reflected. Measurement accuracy is assured *at every frequency*, not just at selected points.

S TECHNIQUE CAN BE USED FOR MOST PRESENTLY KNOWN MICROWAVE TESTING PLICATIONS. HERE'S WHY IT'S FASTER THAN CONVENTIONAL SIGNAL GENERATORS:

Continuous Display allows immediate asurements — no plotting needed. ace can be recorded if desired.

Sweep Technique eliminates time-conming "point-to-point" frequency and wer setting methods of conventional nal generators. Sweep range is continusly adjustable with 1% accurate Direct ading Slide Rule Dial.

"Quick Look Readout" eliminates calations in setting sweep range.

Adjustable Frequency Markers allow pid, broadband calibration of scope or corder trace.

SOME MORE FACTS YOU SHOULD KNOW

* *Frequency Ranges.* The Swept Generator is available in five ranges to 12.4 kmc — 1 to 2, 2 to 4, 4 to 8, 7 to 11, 8.2 to 12.4.

* *Stability.* At any single frequency, stability of the Swept Generator equals that of a conventional signal generator. Spurious modulation is low.

* *Power Output.* Greater than a signal generator: 10 milliwatts as compared to 1 milliwatt.

FUNCTION OF THE LEVELER It holds power output constant to ±1 db over standard frequency ranges, and better than ±1 db over narrower ranges. The Leveler serves as a broadband attenuator with up to 20 db dynamic range control, providing constant output over a wide range. It can be used as a general purpose instrument for a wide variety of oscillators and amplifiers.

For more details on the Alfred Swept Generator — please contact your Alfred sales engineering representative, or write direct.

y specifications for Signal Generators available for coverage from 1 to 12.4 kmc

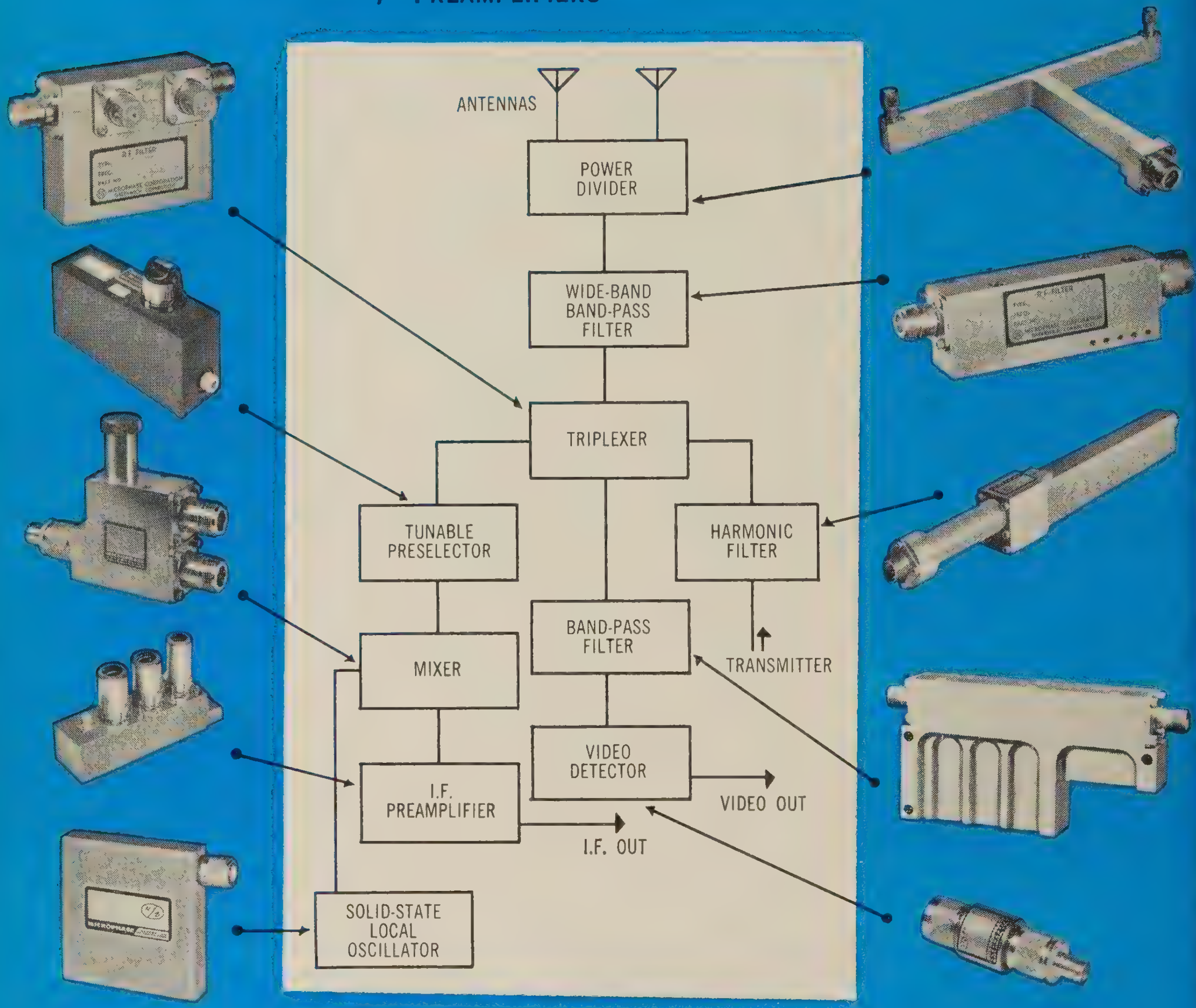
quency — Controls: Continuously adjustable with direct calibrated dial. Calibra- accuracy: 1%. Stability: ±0.02%/hr. Residual FM: ±0.0025%. **Power Output nimum):** 10 mw ±1 db. Continuously adjustable from zero to maximum. **enuation Range:** Up to 20 db. **Sweep** — Selector: Recurrent Sweep, Single Sweep, gle Frequency, and External on panel switch. Time: 100 to .01 seconds, conuously adjustable. **Monitor Output** — Sweep Out: Positive linear sawtooth, 45 ts peak. Panel BNC connector. **Amplitude Modulation** — Internal Square Wave: output is alternately 0 and unmodulated CW value. Frequency 800 to 1200 cps, ustable by panel control.

7

ALFRED ELECTRONICS
897 COMMERCIAL STREET
PALO ALTO, CALIFORNIA

Circle Reader Service Card 46

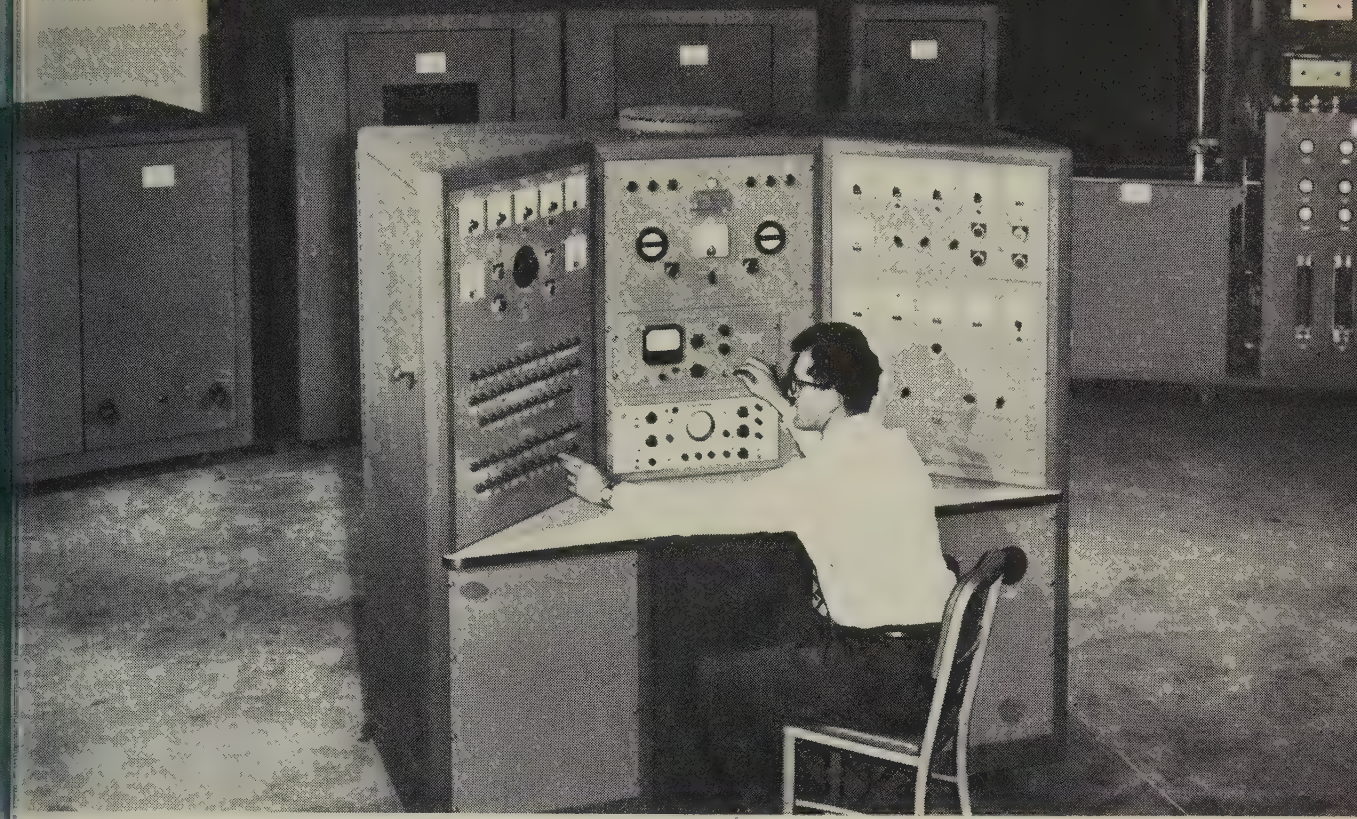
LOW-PASS, HIGH-PASS, BAND-PASS FILTERS
BAND-ELIMINATING FILTERS
CONSTANT-IMPEDANCE FILTERS
WAVEGUIDE FILTERS
BROAD-BAND DIPLEXERS
CAVITY DIPLEXERS
MULTIPLEXERS
PRESELECTORS
MIXERS
CRYSTAL DETECTORS
PRESELECTOR/MIXER ASSEMBLIES
FILTER/DETECTOR ASSEMBLIES
SOLID-STATE DEVICES
PREAMPLIFIERS


ANTENNAS
POWER DIVIDER
WIDE-BAND BAND-PASS FILTER
TRIPLEXER
TUNABLE PRESELECTOR
HARMONIC FILTER
TRANSMITTER
BAND-PASS FILTER
MIXER
VIDEO DETECTOR
VIDEO OUT
I.F. PREAMPLIFIER
I.F. OUT
SOLID-STATE LOCAL OSCILLATOR

Now, from MICROPHASE — complete microwave subsystems. The field-tested reliability of MICROPHASE filters and components is offered in integrated packages for your applications. MICROPHASE ability to match components assures minimum size and optimum performance. MICROPHASE capability includes compatible microwave components between antenna and video or IF circuitry in the range of VHF through the X-Band.

MICROPHASE
CORPORATION

Box 1166W Greenwich, Conn. NO 1-6200 WE 9-9190 TWX GNWICH CONN 759



Model 221M Levinthal modulator (3 megawatts, for SAC 42 klystron).

OMPANY PROFILE

LEVINTHAL Electronic Products, Inc.

Palo Alto, California

During the summer of 1953, Dr. Elliott C. Levinthal d Albert J. Morris met at the Bel-Air Hotel in Los ngeles to informally discuss Morris joining a company vinthal was planning to start in the San Francisco Bay ea. While both men were very intimately acquainted th the talent and technical activities that existed in the ea in the high-power microwave tube field, both also cognized that the area was well populated with many ncerns exploiting that background. It was felt that hat was needed was a concern which would concentrate the technology necessary to properly use the new bes being developed in various kinds of systems. By doing, they would be making use of their knowledge high-power tubes, as well as drawing upon local talents d technological areas that were not being commercially ploited.

In September, 1953 Levinthal Electronic Products, Inc., s founded and occupied a newly-constructed building 2821 Fair Oaks Avenue in Redwood City, Cal. The mpany in particular expected to be able to serve the cal microwave tube manufacturers by supplying them th specialized test facilities for the new tubes that were ing developed and manufactured. It also expected to serve the national market by developing and selling complete r-f packages designed around the same tubes. Shortly after Levinthal Electronic Products, Inc. was formed, the new organization, headed by Dr. Elliott C. Levinthal, was joined by Albert J. Morris as vice president. At the same time Levinthal absorbed the Morris Defibrillator Co., founded by Albert J. Morris and engaged in the research, development, and production of defibrillators and associated medical electronic devices.

One of its first contracts in the high-power transmitter field illustrates the company's carrying out of some of its initial objectives and many of the programs that were to follow in the future. This contract was to build a two megawatt klystron radar transmitter for MTI applications for Rome Air Development Center. It used a high-power klystron, originally developed in the Electronics Laboratory at Stanford University and later manufactured by Litton Industries. Similar early developments took place on transmitters built around tubes manufactured by Eitel-McCullough and Varian Associates. This type of activity continued to expand into what is now known as the Equipment Division. This division has been both

(Continued on page 86)

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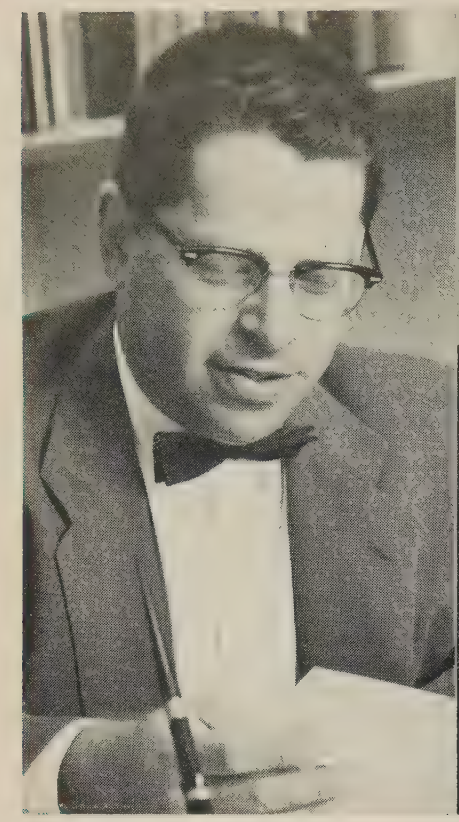
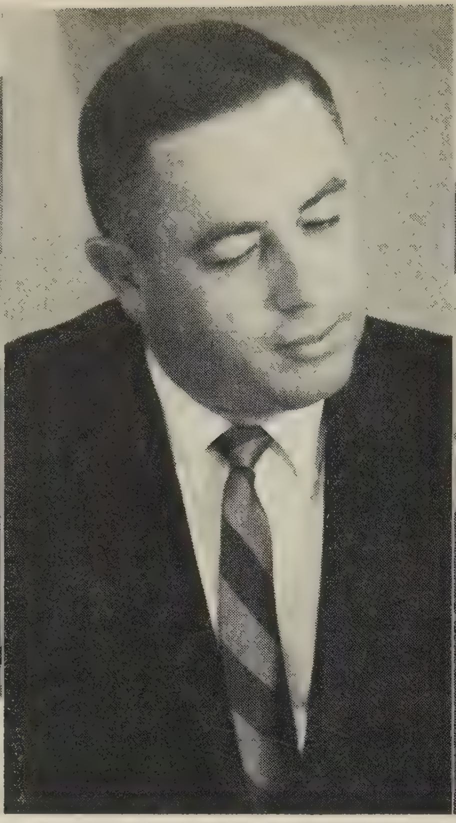


Elliott C. Levinthal, president and general manager.



Herbert R. Morse, vice president and treasurer.

Albert J. Morris, senior vice president, engineering.

LEVINTHAL

(Continued from page 85)

a customer of and a supplier to practically every high-power tube manufacturer in the country. It has built radar transmitters and even complete radar systems located throughout the world. Its high-power transmitters have scattered r-f energy from Alaska to Scotland. It serves as a major subcontractor of transmitters and modulators to many of the largest electronic companies in the country, as well as a prime contractor for all of the military services and many of the larger research institutions in the United States.

Levinthal Electronic Products, Inc., was one of the pioneers in developing techniques for modulating high-power microwave tubes with high impedance electrodes. It holds several patents in the field and as the number of tubes with such electrodes has increased, and the importance of their applications in special high performance radar and communication transmitters has grown, Levinthal Electronic Products, Inc. is increasingly looked to nationally as an expert in this field. Along with the growth of special modulating techniques has been the requirement to handle higher and higher average and peak powers for both hard-tube and line-type pulse modulators, as well as high power c-w transmitters. To keep ahead of the technical requirements for higher power systems, Levinthal undertook research and development activities in the investigation of high-current spark gap switches, new crowbar protective circuits, and special test components such as non-inductive loads for high power tubes as well as new concepts of high-power magnetic modulators.

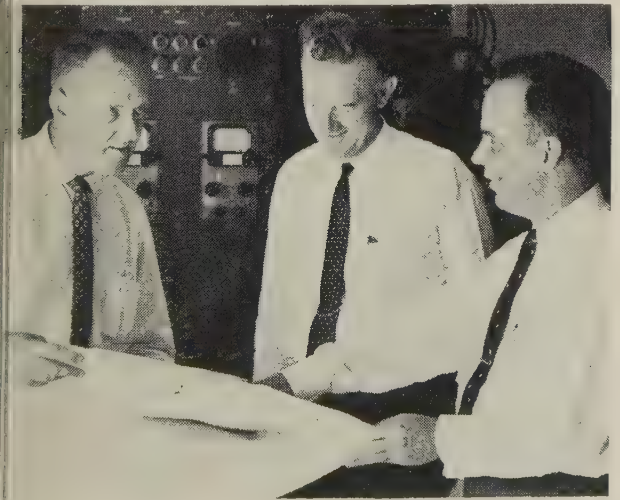
This growth in activity required a corresponding growth in personnel and facilities. Levinthal's busines which has often been characterized by dealing with larg single systems with difficult specifications and often nea ly impossible delivery requirements, necessitated findin people with the courage to take chances and at the sam time the ability to make the chances pay off in the for of successfully completed projects. It was felt that peopl like that could be attracted to a new and growing organ zation by offering them an opportunity to participate i the growth of the company by buying stock in Levintha Electronic Products, Inc. From the very beginning, a employees were given the opportunity to purchase stoc in the company. Throughout its history more than hal of the employees were also stockholders. As an additiona incentive, some of the key employees were also offere stock options. Growth of the company required not onl technical skills in the engineering field but technica skills in the area of financial management. In Decembe of 1954, Herbert R. Morse joined the company as vic president and treasurer and the third member of th company's management team.

Initially the Board of Directors of Levinthal Electroni Products, Inc., consisted of Elliott C. Levinthal, Albert Morris, and Philip S. Mathews of the San Francisco lega firm of Ackerman, Johnston, Johnston, and Mathews. A the company grew it was felt that it was desirable t broaden the viewpoints represented on the Board of Di rectors and enlarge it to include directors not concerne with the direct management of the company. In 195 Joseph M. Pettit, dean of Stanford University School o Engineering, and Benjamin B. Mittelman, a local indus trialist, attorney, and graduate civil engineer from th University of Illinois, were elected to the Board of Di rectors.

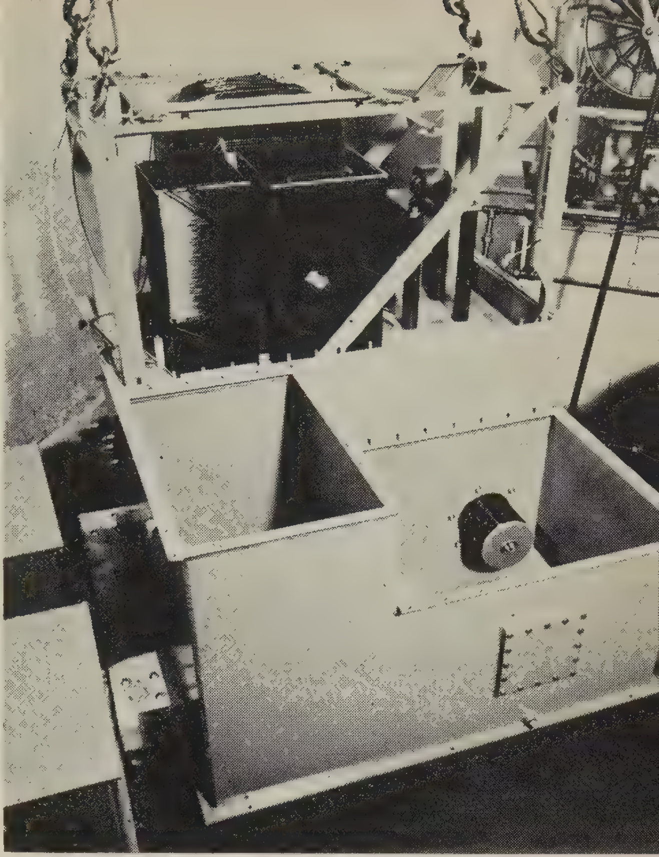
wo of the present members of the senior staff joined company early in 1954. Eldon Anderson, formerly duction superintendent at Lenkurt Electric Co., is duction manager and has been responsible for all duction activities at Levinthal almost from its incep- a. Joseph P. Swanson, assistant chief engineer, also ned the company in its first year of operation and was ponsible for the design of several of its products in medical electronics field, as well as for its initial elopments and some of its inventions connected with cial modulators, to operate in conjunction with high pedance electrode in high-power microwave tubes. ny of the company's later developments were an out- wth of this early effort.

rom 1955 to 1957, others of the present Senior Pro- Engineers joined the staff. First was Gene E. Tall- dge from Stanford University who developed at Levin- l, among other projects, SRI's moon bounce nsmitter, Columbia University's ORDIR radar nsmitter with 10,000 μsec pulses flat to one part in 000 operating at 60 kw peak power, and a 10 kw und-to-air data link transmitter for the SAGE system. was followed by Eli M. Goldfarb, who also came from nford University and who at Levinthal has been re- nsible for the spark gap and magnetic modulator grams, as well as most of their developments in line- e high-power modulator and transmitter systems such he AN/MPS-21 Marine Corps radar system. At about same time, Louis L. Fisher joined the company, com- from Lenkurt Electric Co. At Levinthal he has been onsible for many of their c-w transmitter systems h as the transmitters for the Azusa Missile Tracking tem.

Levinthal Electronic Products, Inc., has found its ximity to Stanford University an advantage in many ys. One of these ways was its participation in the nford Honors Program which permits its engineers to rk at Levinthal and at the same time complete their rk at Stanford for graduate engineering degrees. Roby Blessing, senior project engineer, was the first Levin- l participant in this program. At Levinthal he has eloped many special hard-tube modulators and as- iated transmitters, including a CAA TACAN ground ion transmitter. This transmitter illustrated the unusual gaussian pulse characteristics that could be achieved using techniques associated with high-impedance electrodes in klystrons.



gineering conference includes, left to right, Eldon An- son, production manager; Harry G. Heard, chief engineer; Robert V. Johnson, manager of applications engineering.



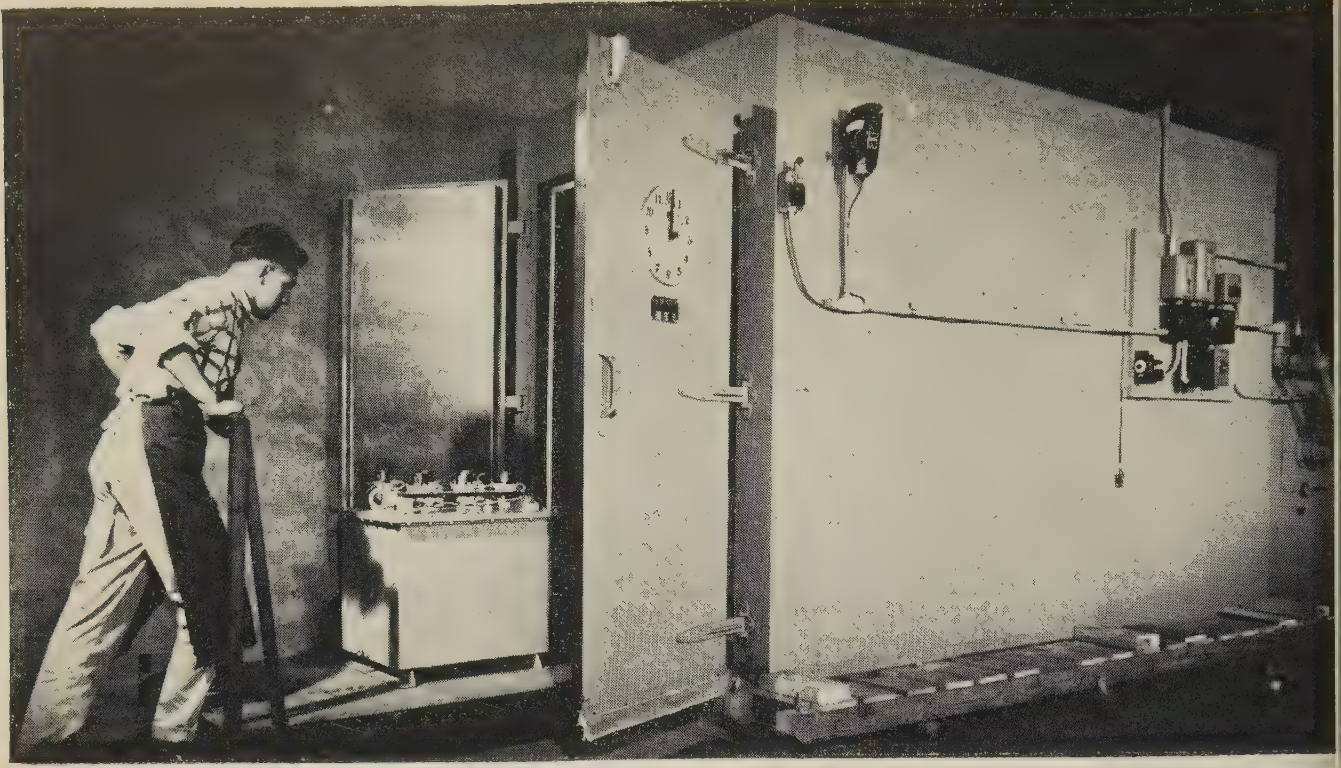
Example of a large Levinthal pulse-transformer assembly produced for Litton Industries tube division.

As the technical requirements of modulators and transmitters became more difficult to achieve, Levinthal Electronic Products, Inc. decided that it would strengthen its position considerably in this field by starting its own transformer department, specializing in high-powered pulse components. This was initiated in 1957 by Howard L. Jessup, manager, Transformer Department, who came to Levinthal from Westinghouse Electric Corp.

Continued growth of the company depended not only on the ability to find talented people, but the willingness of the officers of the company to really delegate responsibility to others working for them. In the beginning Elliott C. Levinthal and Albert J. Morris could depend upon their own efforts to make all the necessary sales contacts and could assume direct engineering responsibilities on many of the projects. Now these responsibilities have been delegated to Harry G. Heard, chief engineer, who came to Levinthal from the University of California Radiation Laboratory where he was responsible for the operation and development of the 6.4 BEV bevatron. Harry Heard brought to the company considerable background applicable to the super-power equipment field. Robert V. Johnson as manager, Application Engineering, assumes responsibility for Levinthal sales activity in the equipment field. He came to Levinthal from Lenkurt Electric Co.

New buildings paralleled this growth of personnel. By the middle of 1956, plans were underway for a new factory and office building in the Stanford Industrial Park

(Continued on page 88)



A typical large pulse transformer is rolled into the baking oven in the Levinthal transformer department.

LEVINTHAL

(Continued from page 87)

adjacent to the University in Palo Alto. The ground breaking was held on Friday, August 3, for the first unit in a planned four-acre future development. At this point the forty-ninth equipment contract was being completed — a transmitter operating in the 225-400 mc band and producing up to 60 kw peak power.

By the end of 1957, the general activity had increased, requiring the addition of the second unit in the planned development bringing the total square feet at Stanford University at that time to 25,000 square feet. Part of this space was occupied by the new transformer activity. At the beginning of Levinthal's sixth year there were 75 employees in the Stanford Industrial Park plant. This was September of 1958. Levinthal had ended the fiscal year with sales in excess of 1.3 million with a growth in each year in excess of 50 per cent over the previous year. At this point the stockholders' equity was slightly in excess of $300,000 compared to an initial investment of a little less than $100,000. The company has always sought a good return on its average equity as well as the growth in sales. Its net income as a per cent of average equity has exceeded 25 per cent in every year except its first.

On March 3, 1959, an announcement was made jointly by Homer R. Denius, president of Radiation Inc., Melbourne, Fla., and Dr. Elliott C. Levinthal that discussions were in progress leading to a possible merger between the two firms. Completion of these discussions and the consummation of the merger were announced on May 1, 1959, and Levinthal Electronic Products, Inc. became a wholly - owned subsidiary of Radiation Inc. The merger was motivated on Radiation's part by both their desire to expand in fields complementary to their Florida activities in the space communications, telemetry, and r-f fields, and a desire to have a West Coast association. On Levinthal's part it was felt that a merger of this kind woul increase the opportunities to participate in larger an larger systems programs. Levinthal's growth in the high power transmitter field has led it to compete for th production of transmitters whose unit costs exceeded on million dollars. This kind of activity would benefit b the added strength gained from an association with larger company.

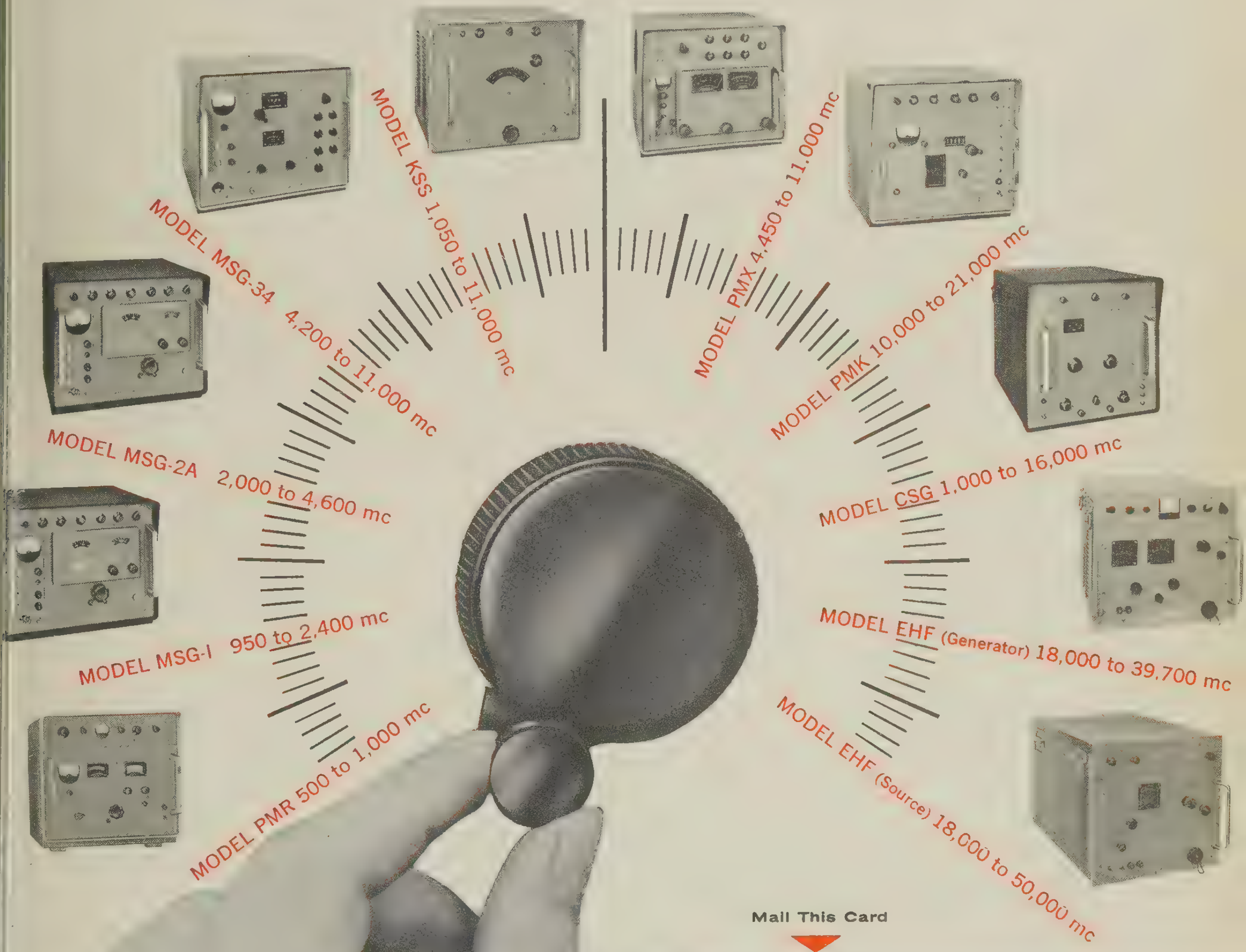
The merger has been in successful operation for over year. Levinthal is run autonomously as a separate corporation with its same management and its own Board o Directors. Formal relationships between the two companies are maintained by the addition of George S. Shaw vice president of Radiation Inc., as a director of Levintha Electronic Products, Inc. and Elliott C. Levinthal as Director of Radiation Inc. New areas of growth for bot companies are expected as the result of joint activities i the systems field. Levinthal's reputation with its customer coupled with its autonomous position with respect t Radiation permits it to continue to serve the customer as a team bidder, even under situations where it has als teamed up with Radiation as a prime for the same system requirement.

Since its merger with Radiation, Levinthal's growth ha continued. Thirteen thousand square feet of new factor facilities have been added and plans have been finalize for a new two-story 12,000 square foot office building o the original four acre site. Completion of this will giv over 50,000 square feet of space, providing working are for approximately 200 employees. These facilities shoul permit Levinthal to double its sales from its present leve which is in excess of $2,000,000 per year. Levinthal expects its growth to steadily increase as the requirement of space communications, missile and radar systems demand larger and more sophisticated modulators and transmitters.

POLARAD

MICROWAVE GENERATORS

500 mc to 50,000 mc


MODEL PMR 500 to 1,000 mc
MODEL MSG-1 950 to 2,400 mc
MODEL MSG-2A 2,000 to 4,600 mc
MODEL MSG-34 4,200 to 11,000 mc
MODEL KSS 1,050 to 11,000 mc
MODEL PMX 4,450 to 11,000 mc
MODEL PMK 10,000 to 21,000 mc
MODEL CSG 1,000 to 16,000 mc
MODEL EHF (Generator) 18,000 to 39,700 mc
MODEL EHF (Source) 18,000 to 50,000 mc

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Please send me information and specifications on

☐ Model PMR
☐ Model MSG-1
☐ Model MSG-2A
☐ Model MSG-34
☐ Model KSS
☐ Model PMX
☐ Model CSG
☐ Model PMK
☐ Model EHF (generator)
☐ Model EHF (source)

POLARAD

☐ A copy of "Notes on Microwave Measurements."

My application is__________

Name__________

Title__________Dept.__________

Address__________

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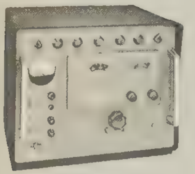
POLARAD

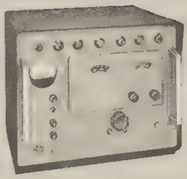
MICROWAVE GENERATORS

500 mc to 50,000 mc

MODEL MSG-I

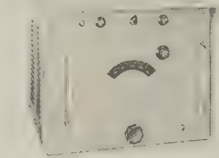


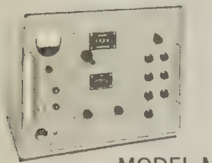
MODEL PMR



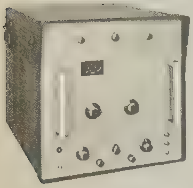
MODEL MSG-2A

MODEL KSS



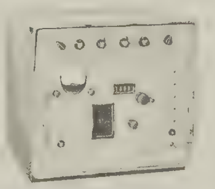


MODEL MSG-34

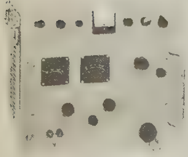


MODEL CSG

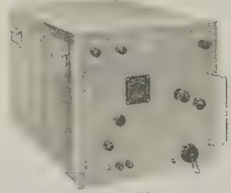
MODEL PMX



MODEL PMK



MODEL EHF (Generator)



MODEL EHF (Source)

MOST FEATURES

MODEL PMR	500 to 1,000 mc	Complete modulation capabilities — internal pulse modulator or FM modulator
MODEL MSG-1	950 to 2,400 mc	Complete modulation capability including square wave modulation
MODEL MSG-2A	2,000 to 4,600 mc	Complete modulation capability including square wave modulation
MODEL MSG-34	4,200 to 11,000 mc	Widest frequency range in a single instrument
MODEL KSS	1,050 to 11,000 mc	Compact high power signal source with plug-in tuning units — internal modulation
MODEL PMX	4,450 to 11,000 mc	Calibrated 1 milliwatt signa generator with complete modulation capability
MODEL CSG	1,000 to 16,000 mc	Higher power sweep generator
MODEL PMK	10,000 to 21,000 mc	Wider modulation capabilities — calibrated 10 milliwatt output
MODEL EHF (generator)	18,000 to 39,700 mc	High frequency signal generator — operates on fundamentals
MODEL EHF (source)	18,000 to 50,000 mc	Widest and highest continuous frequency range — operates on fundamentals

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POLARAD ELECTRONICS CORPORATION

43-20 34th Street, Long Island City 1, N.Y.
Representatives in principal cities.

(Continued from page 82)

This new generator is direct reading and s two frequency ranges changed by a vitch on front panel without the need for anging cavities. For low output position, attenuator of 80 db range is available.

The new UHF power signal generator Type SLRD) can perform many tasks for hich a series of generators has been necesry in the past. For example, it permits the diation characteristic of antennas to be etermined and measurements to be carried ut on filters and four-terminal networks of igh attenuation. Measurements also can e made on wattmeters and on directional ouplers of high coupling attenuation and irectivity.

Rohde & Schwarz also has designed the ype SLRD generator for use as a generator or impedance, VSWR and attenuation measrements and for various calibration proedures for which a known power is necssary.

A data sheet (410 040) covering specificaons, description and uses of Type SLRD HF power signal generator is available n request.

ircle Reader Service Card No. 105

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NEW LINE OF FERRITE DEVICES ANNOUNCED BY BENDIX

A new family of ferrite devices has een announced by the Red Bank Diviion of Bendix Corp., Eatontown, N.J. The first models, all of which are mmediately available, are a new C-Band Electrically Variable Attenuator, model TFA-1; a C-Band Electrically Varible Phase Shifter, model TFP-1; and a C-Band Y Circulator, model TFC-1.

The C-Band Electrically Variable Attenator, model TFA-1, is a reciprocal ferrite evice with oustanding electrical performnce. The attenuator features broad attenution range and broad bandwidth.

This device is a solid solution to numrous system problems, especially suitable n fast AGC circuits and remote levelontrol applications. It will also serve as modulator or as a fast-acting switch.

The C-Band Electrically Variable Phase hifter, model TFP-1, is designed to meet xacting systems' requirements. This ferite device is reciprocal in nature and has phase shift range from 0 to 150 degrees ver a frequency band from 5200 to 5800 nc. The phase shifter also features comactness as well as broad bandwidth.

The phase shifter is ideally suited for se as a phase modulator or, when comined with appropriate hybrid functions, s a fast-acting switch. It can also be used n a large variety of RF direction finding pplications.

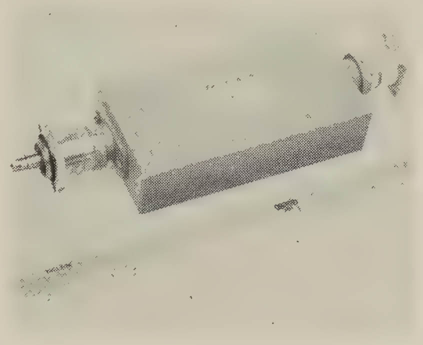
The C-Band Y Circulator, model TFC-1, eatures a combination of exceptional elecrical performance and compact size. This ompact unit has 20 per cent bandwidth, with minimum isolation of 22 db.

The Y Circulator is suited for missile and space vehicle applications and also for use with masers and parametric amplifiers. If one of the parts is properly terminated, it will also serve as a broad band isolator.

Circle Reader Service Card No. 106

—*mwj*—

SPERRY ANNOUNCES FIRST UHF STRIP TRANSMISSION LINE ISOLATORS



Sperry Microwave Electronics Co., Clearwater, Fla., announces the development of a series of miniaturized UHF Strip Transmission Line Isolators. These units can be designed for operation from below 300 to above 1000 mc. The two basic units designed for operation at J- and P-bands, and designated as models D44J7 and D44P1-5 respectively, operate over 10 per cent bandwidths. They exhibit isolations of 10 and 20 db and insertion losses of 1.0 and 1.2 db for the 400-450 and 870-990 mc band, respectively. The isolators measure only 1.5 inches x 3.0 inches x 7-37/64 inches length, and weigh 2½ pounds each.

Potential applications for these miniaturized isolators include their use in telemetry, radar, and communications systems; missile and aircraft equipment; and laboratory equipment. Their primary advantages are their excellent electrical performance, small size and weight, and relative insensitivity to external magnetic influence.

The two models indicated above are available for delivery from stock in small quantities, or in production quantities with delivery beginning 30-60 days after order. They are also available in other frequency bands and over broader bandwidths on special order. The stock units are intended for low power applications up to 10 w cw although higher power units can be designed for particular requirements utilizing the present design techniques.

Circle Reader Service Card No. 107

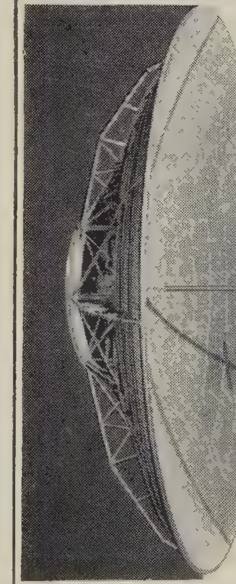
—*mwj*—

PHILCO-LANSDALE COMPLETES DIODE LINE FOR K— AND K_u—BAND OPERATION

With the addition of two new microwave diodes, announced bv Charles McCarthy, sales manager-diodes, of the

(Continued on page 92)

AINSLIE ANTENNAS



.......for the 100-500 mc BAND

MODEL CF121M — 12 ft. diameter with dipole exciter. Gain 23 db at 500 mc. Minimum side lobes 20 db (or better). Cross Polarization 20 db (or better).

Low VSWR at any frequency in the band. Accomplished through adjustable balun and reflector assembly.

STOCK REFLECTORS—4 in. to 10 ft. diameter solid spun. 4 ft. to 18 ft. diameter mesh. Larger sizes or special shapes on request. Antennas up to 10,000 mc.

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Any type antenna or reflector precision-built to your specifications.

Write for complete performance data sheets.

MODEL CF141M with 14' diameter reflector available

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Designers & Manufacturers of Microwave Antennas & Associated Equipment

Circle Reader Service Card 48

(Continued from page 91)

Lansdale, Pa. Division, Philco now has one of the most complete lines of low-noise mixer crystals for K- and K_u-band operation in the industry.

The new diodes, 1N26BR and 1N78DR, are the electrically reverse versions of the 1N26B and 1N78D. Last year Philco introduced the 1N26B and 1N78C as the lowest noise figure crystals in the silicon coaxial families for 24.000 and 16.000 mc applications respectively.

With both forward and reverse types now available, balanced mixer operations are readily facilitated.

The 1N78DR features a very low overall noise figure of 7.5 db. Overall noise figure of the 1N26BR is 10 db. Such low noise operation greatly increases radar range and sensitivity.

As with their forward polarity counterparts, both reverse crystals feature a metal-to-ceramic hermetic seal within the crystal cartridge which affords the diodes a capability to withstand 150° operating temperatures.

Philco's complete line of forward and reverse type silicon mixer diodes for 24,000 and 16,000 mc applications includes 16 distinct coaxial crystals.

Delivery of the new diodes in production quantities can be made within two weeks of notice. Unit prices in the two series range from $9.00 to $72.00 for quantities of 100 and up.

Circle Reader Service Card 108

—mwj—

NEW GE THYRATRON

A new, high-power hydrogen thyratron, type Z-5101, has been added to the family of heavy-duty switch tubes manufactured by General Electric's Power Tube Department, Schenectady, N. Y.

Because of the new tube's high ratings and rugged ceramic - metal construction, it is ideally suited for operation in the extreme conditions of radar modulator and other pulsing service.

The Z-5101 substantially extends the power switching capabilities of General Electric's hydrogen thyratron line, with increased peak power and average power ratings as well as a greatly increased anode dissipation factor.

Peak power is 48 mw; peak forward anode voltage is 40 kilovolts; and peak current is 2400 amps. At this level, average power si 44 kw and average current is 2.4 amps.

At other peak power levels, average powers as great as 80 kw and average currents as great as 4 amps can be attained.

When operated at maximum ratings, the tube is water-cooled at one gallon per minute by means of a coil in the external anode.

Because of its high anode dissipation factor of 45x10^9, and its rugged construction, the Z-5101 is being considered for use in mobile radar systems.

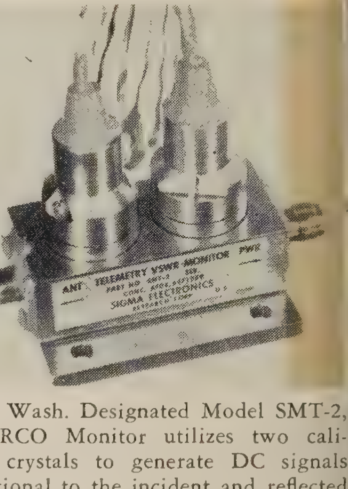
Overall length (excluding flexible leads) is 16 inches. Diameter is six inches and weight, 10 pounds.

It is available in sample quantities. An original equipment manufacturer price of $2,800 has been set.

Circle Reader Service Card 109

—mwj—

MISSILE-BORNE VSWR MONITOR INTRODUCED



A new VSWR Monitor, qualified for missile flight, has been introduced by Sigma Electronics Research Corp., Seattle, Wash. Designated Model SMT-2, the SERCO Monitor utilizes two calibrated crystals to generate DC signals proportional to the incident and reflected RF power.

The SMT-2 has 120 watt CW power capacity. Output is 50 millivolts DC with 50 watts RF in. VSWR is less than 1:05 to 1:00 and insertion loss is less than .2 db. Accuracy is ±5 per cent; it weighs less than 9 ounces and has directivity greater than 25 db.

The SMT-2 can be built to operate at any narrow band between 100 and 5000 mc/s up to 1000 watts.

Circle Reader Service Card 135

—mwj—

BOGART INTRODUCES NEW C-H BAND BALANCED MIXER

A new C-H Band Balanced Mixer introduced by Bogart Manufacturing Corp., Brooklyn, N.Y., is composed of a broadband hybrid and two broadband crystal holders. Proper filters and chokes

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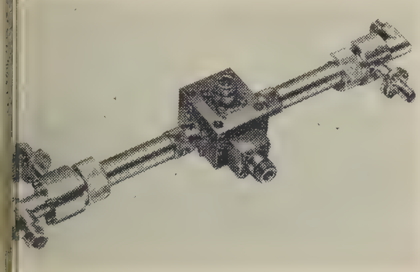
constructed internally in order to tain minimum conversion loss and SWR.

The frequency range of the local oscil- tor is 3900 to 4500 mc; the signal quency range is 5200 to 5800 mc and



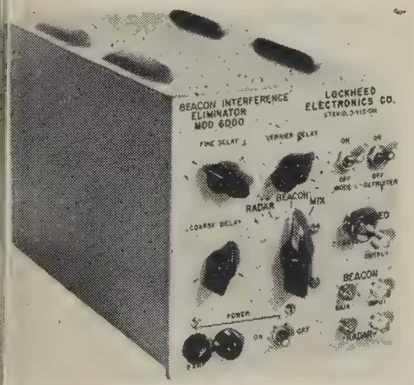
e IF frequency is constant at 1300 mc. his facilitates the use of a local oscil- tor and signal locked together so that is possible to obtain a varying signal- cal oscillator system which does not re- ire very narrow band electronically ned filters. The conversion loss is 6 db er the band, and the VSWR is less than 1 over the L.O. band, and less than 7:1 over the signal frequency band.

The configuration of the mixer is xible so that the crystal holders may positioned to reduce the overall size the package. The IF frequency can fixed constant at any point in the crowave spectrum, depending upon the rticular customer application, and op- num mixer characteristics can be ieved. One novel application is the uble-superheterodyne system where all mponents, following the mixer, are esigned for use at a single frequency, ther than a band of frequencies, en- bling optimal performance of each of e components.

Circle Reader Service Card 110

—mwj—

NEW BEACON INTERFERENCE ELIMINATOR DEVELOPED BY LOCKHEED ELECTRONICS



A new device developed by Lockheed lectronics Co., Plainfield, N.J., elimin- tes spurious signals, known as "fruit," rom radar displays.

In air traffic control applications, the eacon Interference Eliminator, model 000, may be used with any standard adar having a beacon capability for IFF r ATC identification. It assists in lo- ating and identifying aircraft, without isplaying distracting spurious signals caused by over-interrogation, clutter, weather or other phenomena. In tactical military situations, the Eliminator differentiates between radar returns from targets and unwanted signals produced by interference, intentional or otherwise.

No modification is necessary for use with any standard radar. The device is connected into the video lines connecting the radar-beacon receivers with the display.

"Defruiting" is accomplished through passive operation, with the output being proportional to the input. The size of the blip on the display, therefore, is proportional to the target's size and range. The display appears the same as if the Eliminator were out of the circuit and the radar-beacon were operating in a non-interference environment.

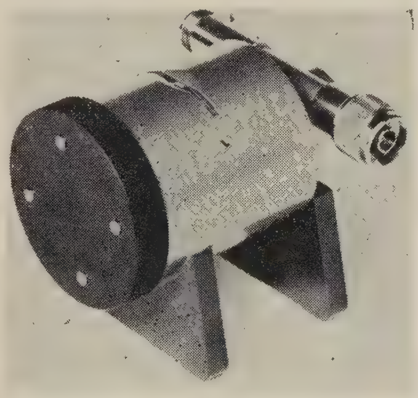
Operation is on a per-scan basis. Information is not stored between beacon or radar bursts, eliminating the need for costly temperature-sensitive scan-to-scan storage devices.

Bulletin MS-101, which describes the operation of Model 6000 and provides electrical characteristics and test results obtained under simulated operating conditions, is available on request.

Circle Reader Service Card 111

—mwj—

FXR COAXIAL FREQUENCY METER OFFERS THREE-BAND RANGE



FXR, Inc., Woodside, N.Y., manufacturer of microwave and electronic equipment, now offers a direct reading coaxial frequency meter, model 414A, with a range from 3.95 to 11 kmc. This coverage of over three waveguide bands extends its usefulness for either coaxial line or waveguide setups and makes it a fitting companion to FXR's model N410A direct reading frequency meter, whose range is 1.00 to 4 kmc. Like its predecessor, its absolute accuracy is 0.10 per cent.

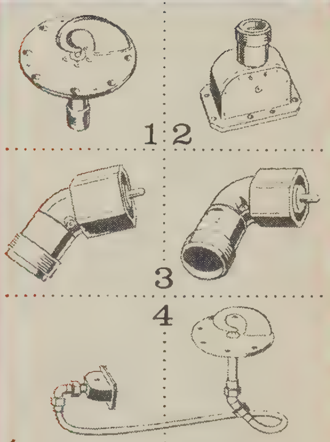
The FXR model N414A direct reading frequency meter is a reaction type instrument, absorbing power only at the resonant frequency of a half wavelength resonant cavity. The mirror-finished cavity surface is silver plated and rhodium flashed. The tuning plunger is a non-contacting choke type with a high resonant Q.

Backlash has been eliminated in the

(Continued on page 94)

ECM/SYSTEMS

BUILDING BLOCKS FOR THE SPACE AGE
by
ELECTRONIC SPECIALTY CO.



1 **SCIMITAR ANTENNA ABS—S 653**
Frequency .... 2350-5000 mc
VSWR .... <1.15:1
Efficiency .... >95%
Power Handling .... 800 Watts cw
Coaxial Impedance ..... 50 ± 2 Ohms
Weight .... 1.0 lbs. max.

2 **WAVEGUIDE/COAX ADAPTER WGC—S—655**
An extremely efficient device designed with very low VSWR. Frequency band from 2350 to 3600 mc. Manufactured in one piece as a solid light weight casting. Features high power (800 watts cw) with low insertion loss (<0.25 db.)

3 **ADAPTERS (45° & 90°) ADC—657 ADC—656**
These adapters are designed for high power applications. *The one piece solid light weight casting provides weight savings. A special slip nut permits fast installation. The dielectric is a solid injection mold.
* These adapters display an extremely low VSWR and high efficiency.

4 **ECM ANTENNA SYSTEM**
These scimitar ECM Systems are designed to pass the most rigid electrical and vibration specifications. Mainly designed for airborne use and fabricated from aluminum for extreme light weight. Similar types can be furnished in frequencies from 225 mc to 12,000 mc. Meeting military specifications ALA-15 (V)

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(Continued from page 93)

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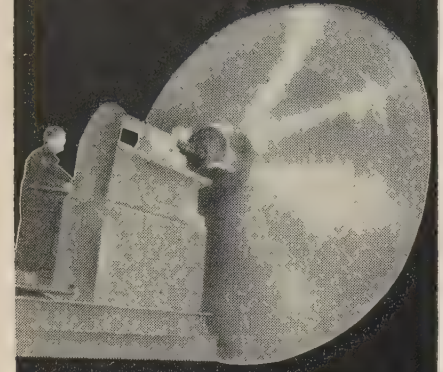
CHARGE



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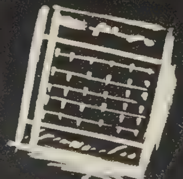

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Circle Reader Service Card 52

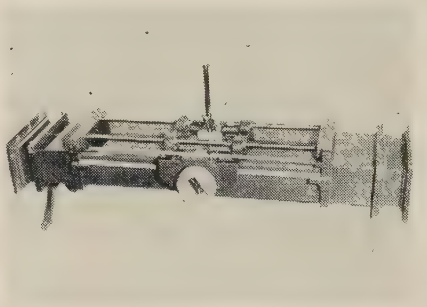
instrument's drive mechanism and smooth operation is further assured by supporting the spring-loaded drive on a precision ball bearing.

An applicable FXR series 601 waveguide-to-coax adapter permits the use of the instrument, with its Type N connectors, in H-, C-, W- or X-Band waveguide setups.

Circle Reader Service Card 112

—mwj—

NEW LARGE WAVEGUIDE SLOTTED LINE IMPEDANCE METERS NOW AVAILABLE



A new line of precision instruments to provide reliable and accurate VSWR measurements on the larger waveguides including the WR2300 and WR2100 types has been announced by Schutter Microwave Corp., Lindenhurst, N.Y.

The instruments are designed with adjustable mounts for ease of alignment, incorporate ball bearing carriages for smooth probe travel and are rugged in construction to insure long life operation.

Schutter offers these units at comparatively lower cost and with prompt delivery. Additional information on these slotted line instruments such as graphical, technical data and cost schedules may be obtained from Schutter Microwave Corp.

Circle Reader Service Card 113

—mwj—

RCA ADDS TWO NEW POWER TUBES TO CERMOLOX LINE

Two new Cermolox power tubes designed for use in missiles and compact aircraft and mobile equipment were introduced to the industry recently by the RCA Electron Tube Division, New York, N.Y.

The new tubes are small, forced-air-cooled, ultra-high-frequency beam power types, featuring coaxial-electrode construction, which have been designated RCA-7650 and -7651, according to C. E. Burnett, division vice president, Industrial Tube Products Department.

RCA's Cermolox line is a recently-adopted name for a family of beam power tubes that feature ceramic-metal construction, precision alignment of grids, he explained.

With these two new tubes, RCA now has seven types commercially availabl and expects to add two more by the en of 1960. The complete line, Mr. Burnet said, will cover power levels from 25 t 10,000 watts plate dissipation and frequency up to 3000 megacycles.

Mr. Burnett said both types can tak vibrational accelerations at 20 g and ar able to withstand shock impacts as grea as 500 g.

"Both tubes," he said, "have maximum plate dissipation of 600 watts and can b operated with full ratings at frequencie up through the Aeronautical Radio Navigation Band of 960 to 1215 megacycles. They also are useful at higher frequencies.

"The coaxial-electrode structure employed in the 7650 and 7651 makes them adaptable to either coaxial-cylinder o parallel-line circuits. Both utilize RCA' exclusive grid-making technique for precision grid line-up and exceptional structural rigidity. The perfect alignment o grids provides maximum tube operatin efficiency."

The 7651 is designed for pulse operation and can deliver a peak power outpu of nearly 40 kw at 1215 mc.

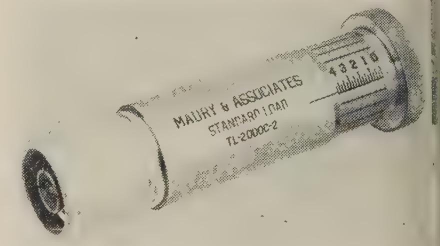
The 7650 when used under continuou commercial service conditions as a radio frequency power amplifier and oscillato in class C telegraphy service, has a maximum plate-voltage rating of 2500 volt and a maximum plate-input of 1250 watts

RCA-7650 and 7651 are commercia designations for developmental types A 2572 and A-2585-A, respectively.

Circle Reader Service Card 114

—mwj—

MAURY & ASSOCIATES INTRODUCES NEW TUNEABLE PRECISION STANDARD COAXIAL TERMINATION



Maury & Associates, Pomona, Cal., has introduced its newly developed standard tuneable matched load (patent applied for).

Not to be confused with a sliding termination, this new precision laboratory instrument provides a new dimension in slotted line measurements, being capable of reducing its own reactive elements to a negligible value, where the VSWR measured is the residual VSWR of the line. In addition, the load can be precisely calibrated in terms of known VSWR and phase components so that a voluntary mis-

140 KMC

ULTRAMICROWAVE*
EQUIPMENT
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– it works

– it's accurate

– it's available

omplete data on request

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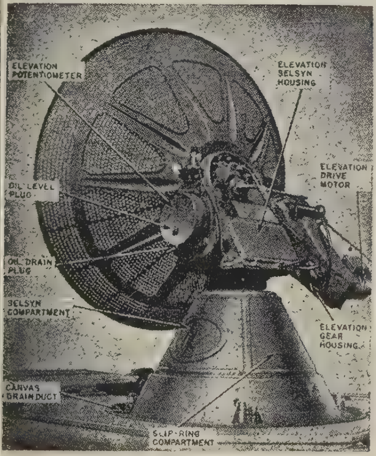

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SCR 584—MP 61B

Full azimuth and elevation sweeps. 360 degrees n azimuth. 210 degrees in elevation. Accurate o ¼ mil. or better over system. Complete for full racking response. Angle acceleration rate: AZ. 9 egrees per second squared EL.4 degrees per second quared. Angle slewing rate: AZ 20 degrees per ec. EL. 10 degrees per sec. Angle tracking rate: 0 degrees per sec. Includes pedestal drives, selsyns, otentiometers, drive motors, control amplidynes. Excellent condition. Quantity in stock for immediate shipment. Ideal for missile & satellite racking, antenna pattern ranges, radar systems, adio astronomy, any project requiring accurate esponse in elevation and azimuth.
Complete description in McGraw-Hill Radiation Laboratory Series, Volume 1, page 284 and page 09, and Volume 26, page 233.

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Circle Reader Service Card 54

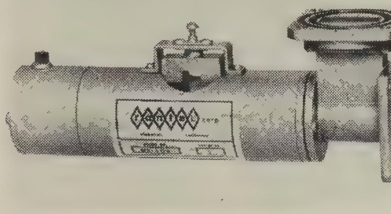
match can be introduced without removing the load.

Two models are currently available: the TL-2000 covers the range 250 to 2000 mc, and the TL-4000 covers the range 2000 to 4000 mc. Both models can be supplied with either type N or type C connectors.

Circle Reader Service Card 115

—mwj—

NEW FERRITE SWITCHES DEVELOPED BY RANTEC



Typical of Rantec's new ferrite switch line is the Model SX-102 for the 9.0-10.2 kmc band, with isolation 25 db minimum and less than 1.0 db insertion loss. Switching time is 0.1 microseconds. The unit sells for $550.00 in small quantities. Production quantities are available on this unit and a variety of other ferrite switches as well as associated electronic driver units.

Circle Reader Service Card 116

—mwj—

SYLVANIA ANNOUNCES NEW K-BAND MIXER MICROWAVE DIODE

Sylvania Electric Products Inc., New York, N. Y., has announced a new K-band mixer (24,000 mc) microwave diode which meets all military environmental tests including shock, temperature cycling, centrifuge, and moisture resistance.

Marvin E. Groll, product sales manager — microwave diodes of Sylvania's Semiconductor Division, said the new mixer diode, type 1N26C (negative polarity 1N26RC), uses a coaxial package with a hermetic seal, and has a temperature rating of 150°C.

"The overall noise figure of the 1N26C has been reduced to 9.5 db maximum," Mr. Groll said. It also features a maximum VSWR of 1.5, a maximum conversion loss of 7.5 db, and a maximum noise ratio of 1.5 times.

Circle Reader Service Card 117

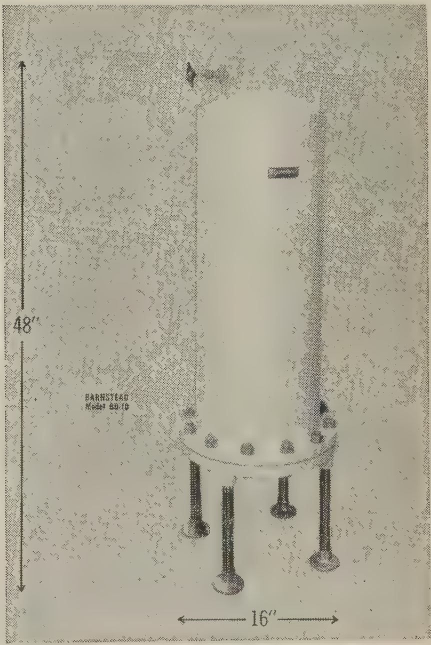
—mwj—

NEW MAGNETIC-CORE DELAY CABLE ANNOUNCED BY COLUMBIA

Columbia Technical Corp., Woodside, N. Y., announces a new, patented delay cable type characterized by extremely wide bandwidth and excellent transmission characteristics. Known as type HH-1500A, the new delay cable features an impedance of 1500 ohms and a delay of 0.08 microsecond per foot with delays on the order

(Continued on page 96)

DEMINERALIZED WATER
AT 1200 G.P.H.
WITH *NEW*
BARNSTEAD
CARTRIDGE
DEMINERALIZER



FOR
use as repurifying demineralizer in high purity rinsing in semi-conductor field.

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use in Cooling Loops of U.H.F. transmitting tubes.

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FIVE
different cartridges — standard, mixed resin, organic removal, oxygen and cation supercartridges . . . all can be used interchangeably in the Barnstead BD-10 Demineralizer.

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Describes Barnstead's complete line of Mixed-Bed, Two-Bed, and Four-Bed Demineralizers. Profusely illustrated with case histories, charts, diagrams and specifications. Write for your copy today!

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FIRST IN WATER PURIFICATION SINCE 1878

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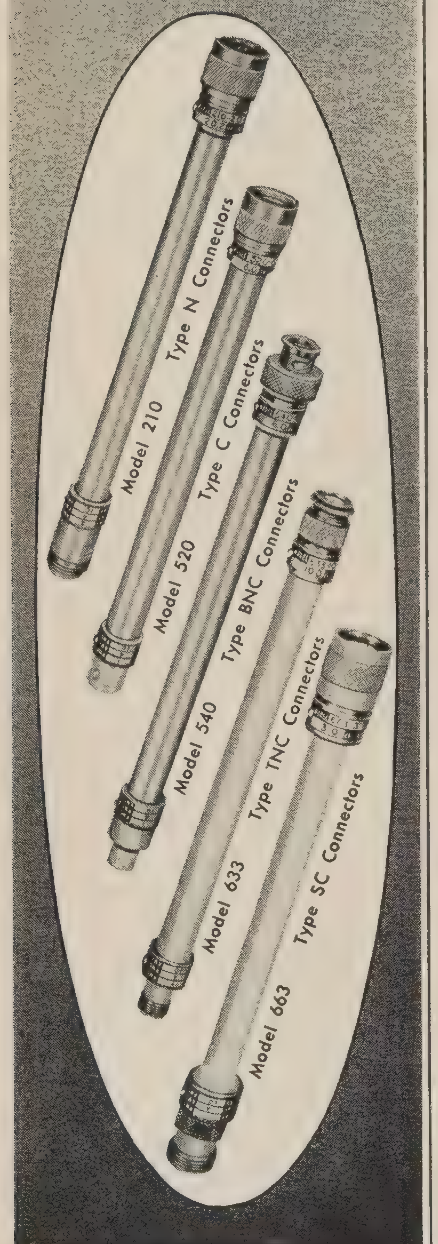
WEINSCHEL

FIXED COAXIAL ATTENUATORS

1 to 12.4 KMC

50 Ohms 1 to 20 db

Connectors: Type N, C, BNC, TNC or SC. Each type with male/female, double male or double female connectors. Made with Weinschel Film Resistors for maximum stability.



WE CO

Write for complete catalog, specifying frequency range of interest.

Weinschel Engineering

KENSINGTON, MARYLAND

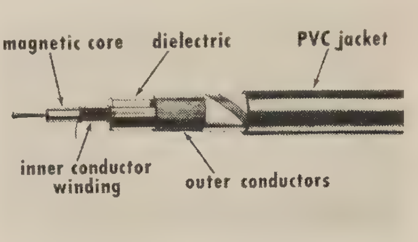
Circle Reader Service Card 56

New Products

(Continued from page 95)

of several microseconds. Ratios of delay-to-rise time of 100:1 can be achieved.

The delay cable has an O.D. of 0.400 inches. It is very flexible and can be easily installed in electronic equipment. It can be supplied in 100 foot bulk lengths or in calibrated sections with molded PVC end caps and tinned leads.



Type HH-1500A is widely used in high quality applications where extreme fidelity of signal transmission is important. The delay cable has been assigned the military designation RG-266/U by the Navy Department.

Circle Reader Service Card 118

—mwj—

NEW HIGH VOLTAGE VARACTORS FEATURE WIDE RANGE OF APPLICATIONS

A new series of diffused junction varactor diodes with high voltage breakdown properties is available from Microwave Associates, Inc., Burlington, Mass.

The complete series MA-4280 through MA-4292 (13 new diodes) range in junction capacitance values from 0.4 $\mu\mu$f measured at —6 volts, to 35 $\mu\mu$f maximum for the MA-4292. Junction capacitance at 0 volts is approximately twice the —6 volt value. At —30 volts, the junction capacitance is approximately one-half its value at —6 volts. The inverse breakdown voltage rating is —30 volts.

Typical cut-off frequency of the new units is 30 kmc except for the large capacitance types which have about 2 ohms series resistance. The diodes are housed in a hermetically sealed, reversible cartridge with ceramic-to-metal seal, and are supplied with a base adapter. The units are mechanically interchangeable with 1N21, 1N23, 1N415, 1N416, 1N21WE, or 1N23WE point-contact diodes and the MA-450 and MA-460 varactor diodes.

High output power with excellent efficiency is reported for the new diodes in many different types of multiplier circuits operating in various types of RF receiver and transmitter equipments in the 1 mc to 10,000 mc frequency range. The new diodes are also being used as high-level modulators for microwave links with output powers of several hundred milliwatts. Other uses include voltage tuning applications, phase shifters, high level RF power metering circuits and other special applications.

Details and an application brochure are available from Microwave Associates.

Circle Reader Service Card 119

NEW HIGH VACUUM VALVE AVAILABLE

A new type ultra high vacuum valv is said to achieve better than 10^{-9} mm Hg in the temperature ranges from —200°C to + 600°C. The metal valve, including copper seal, is designed for application i space chambers, vacuum tube processing particle accelerators and other types o high vacuum systems. It is available i sizes from 1/2 inch to 4 inch I.D. and i reliable for more than one hundred (100 seals per gasket, according to the manu facturer, Vactite Company, Palo Alto Cal.

Circle Reader Service Card 120

—mwj—

IMPROVED HIGH DIRECTIVITY COAXIAL DIRECTIONAL COUPLERS DEVELOPED

A new and improved line of hig directivity broad band coaxial directiona couplers, which provide flat coupling ove a full octave frequency range with low VSWR, has been developed by The Nard Microwave Corp., Mineola, L. I., New York.

Directivity of the new design exceed 30 db. Coupling values of 10, 20 and 3 db are within 1 db of nominal value ove the specified range, with calibration provided to an accuracy of ±0.2 db at five frequencies. Calibrations are permanentl marked on the coupler.

COAXIAL DIRECTIONAL COUPLER
MODEL NO.
SER. NO.
narda
FREQUENCY-KMC

These couplers may be used at lowe frequencies than the specified range Coupling increases below the specified range at approximately 6 db per octave.

Each coupler is machined from solid blocks of aluminum to exacting standards a built-in secondary arm termination is included.

Prices range from \$100 to \$150; the units are available from stock.

Circle Reader Service Card 121

—mwj—

C-BAND TWT DEVELOPED BY GE

A new, low-noise traveling-wave tub for operation in the C-band, is available from the General Electric Power Tube Department, Schenectady, N. Y.

Developed at the department's Microwave Laboratory in Palo Alto, Cal., the new metal-ceramic tube, type Z-3028, covers the 4,000-to-8,000-megacycle frequency range. It has a maximum noise figure of 10 db with an average integrated noise figure of about 8 db. Minimum small signal gain is 25 db. Power output is 5 milliwatts.

Designed primarily as a pre-amplifier for radar receivers, the tube can also be used in a number of other applications including microwave relay systems, radioetry, countermeasures, radio astronomy; a limiter and automatic gain control d as a microwave mixer and frequency vider.

The Z-3028 is "ruggedized" to with- and shock up to 50 g's and vibration 15 g's. It will operate at altitudes as gh as 100,000 feet. It uses permament agnet focusing and is convection cooled.

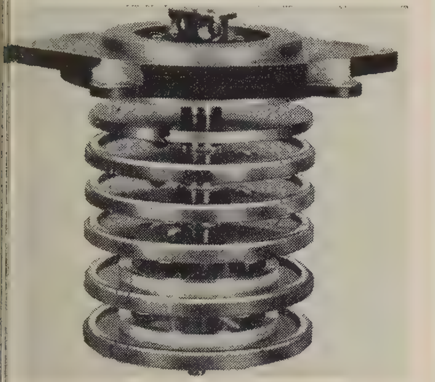
The Z-3028 is supplied as a package mplete with rf and dc connectors at ,850. It is available in sample quanti- es with delivery in 30 to 60 days.

Length is 9.25 inches; width, 4.5 inches; eight, 2.9 inches; weight, 12 pounds. can be installed in any position.

Circle Reader Service Card 122

— *mwj* —

SLIP RING ASSEMBLIES FOR SWITCHING ANNOUNCED



A slip ring assembly of concentric ring pe construction for switching from ositive to negative for sine and cosine unctions in radar antenna mounts has een announced by Breeze Corp. Inc., nion, N. J. The unit accomplishes witching within 0°20'.

Unlimited combinations of segment esigns are available with Breeze rotary witches, and the use of arc resistant in- ulation material permits high power atings. Switching is either break-before- nake or make-before-break. Phasing ccuracy is 0°20' electrical and .005" nechanical. The slip ring assemblies op- rate in an ambient temperature range rom —65°F. to 165°F.

Circle Reader Service Card 123

— *mwj* —

WESTINGHOUSE ANNOUNCES TWO TUNABLE X-BAND MAGNETRONS

Two new tunable, X-band magnetrons — types 7008 and 7111 — have been nnounced by the Westinghouse electron- c tube division, Elmira, N. Y., for service s 220-kilowatt pulse oscillators over the requency range of 8500 to 9600 megacy- les. Both types are recommended as pre- erred replacements for fixed-frequency J50 magnetrons and are functionally dentical except for provisions for tuning: he new WL-7008 magnetron is designed or rapid tuning by servo whereas the WL-7111 is tuned by hand and locked in lace.

Both magnetrons employ a new cou- led-cavity tuning system external to their

(Continued on page 98)

ACTUAL SIZE
MA-214 · MA-217 · MA-219
7500 – 10,000 kMc

EXCELLENT form-factor and operating versatility make these rugged magnetrons ideal for many small-package applications including CW or pulsed radar beacons, test equipment oscillators, airborne navigation, proximity detection, surveillance, and transponder type operations.

Light, dependable, and with proven capabilities, these tubes operate at 500 to 600 peak volts and 150 ma peak pulsed current, permitting low-cost modulator components for all applications. They give a nominal power output of 1 watt CW and 15 watts peak.

Engineering programs in progress at Microwave Associates are directed towards development of this tube as a voltage-tunable magnetron within the same form-factor. Your inquiries are welcomed on these and other magnetrons.

A copy of our new 72 page Magnetron Catalog is available upon written request on your company letterhead.

MICROWAVE ASSOCIATES, INC.
BURLINGTON, MASSACHUSETTS
Western Union FAX • TWX: Burlington, Mass., 942 • BRowning 2-3000

Circle Reader Service Card 57

NEW REDESIGNED AND EXPANDED LINE OF MINIATURE OSCILLATOR CAVITIES

from 800-7000mc by
TRAK ELECTRONICS COMPANY

From its twelve years of research, development and experience with microwave oscillator cavities, TRAK now announces two new standard cavities:

(1) TRAK Type 9127-C for C-Band Pulse Service, 5400-5900 mc, pictured above.

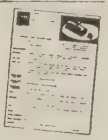
(2) TRAK Type 9127-S for S-Band Plate or Grid Pulse Service and as a CW oscillator, operating in any 300mc part of 2700-3600mc.

Other cavities engineered to customer specifications, 800-7000mc.

TRAK cavity Type 9127-C is shown above and its specifications are:

Frequency	Tunable from 5400—5900mc. Tuning done by adjusting a screw located on one end of the cavity.
Tube Type	G. E. 7486.
Power Out	Greater than 50W peak minimum over the band. (0.002 duty cycle, 1 microsecond pulse, 1000 volt pulse at approx. 0.7 amps. Higher powers obtained by using higher pulse voltages.) Depending upon the individual tube, output powers exceeding 100W peak have been obtained.
Output Pulse Rise Time	Less than 25 millimicroseconds.
Leading Edge Jitter	Approx. 5 millimicroseconds.
Temperature Stability	±0.05% from 0°C. to +71°C.
Shock	100G for 7 milliseconds in each of 3 major axes results in less than max. ±0.25mc. FM.
Vibration	15G from 50 to 2000cps. in each of 3 major axes results in max. ±1mc FM. Cavity survived 56G at 2000 cycles with less than ±4 mc FM.
Size	1" diameter x 2½" long, excluding output connector and mounting brackets.
Weight	4 ounces.
Output Impedance	50 ohms.
Output Connector	Type TNC.
Mounting	Engineered to customer specifications.

We invite you to write for TRAK Cavity Technical Bulletins.



TRAK
ELECTRONICS

MICROWAVE COMPONENTS DEPT.
TRAK ELECTRONICS CO.
Division of CGS Laboratories, Inc.
55 Danbury Road, Wilton, Conn.
Tel: POrter 2-5521

Circle Reader Service Card 58

New Products

(Continued from page 97)

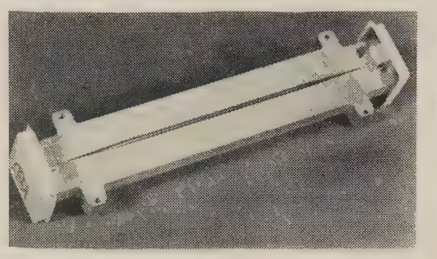
vane-type resonator systems and have exceptionally uniform characteristics across the entire operating band. Excellent spectra results at pulse widths as great as 2.5 microseconds.

Mechanically, both magnetrons withstand vibration well, have high thermal stability, and can be mounted in any position. Their waveguide output is designed to couple with a modified UG-52A/U choke flange. Although they can be pressurized, no breakdown will occur at pressure of one atmosphere.

Circle Reader Service Card 124

—*mwj*—

HALF-X SLOTTED SECTION INITIATED



Initiating a new line of special test equipment and components to be known as Half-X components, Turbo Machine Co., Lansdale, Pa. announces a slotted section in Half-X waveguide. Designed to mate commercially available carriages, this device permits accurate measurement of impedance and VSWR in 0.900 x 0.200 inch ID waveguide.

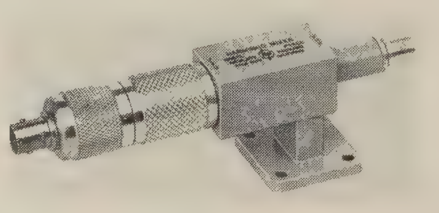
Tests which formerly required use of transformer sections can now be performed with minimum incidental error. Slope and distortion are minimized through close tolerance construction. Residual VSWR of the section is less than 1.03:1. Flanging consists of a modified UG-39/U configuration.

In addition, Turbo has recently made available transformer section, terminations, hybrids and adapters in Half-X.

Circle Reader Service Card 125

—*mwj*—

HEWLETT-PACKARD OFFERS NEW HARMONIC MIXERS



Two new harmonic mixers which speed and simplify frequency measurements up to 18 kmc are now available from Hewlett-Packard Company, Palo Alto, Cal.

Model P932A fixed tuned harmonic mixer, operating in the 12.4 to 18 kmc P-Band, mounts directly in a waveguide system and operates with a Hewlett-Packard Model 540A or 540B transfer oscillator. The oscillator output is applied directly to the mixer, which generates harmonics and mixes them with an applied unknown waveguide frequency. The mixer's beat frequency output is applied to the 540's oscilloscope, the oscillator tuned for zero beat scope indication and the oscillator frequency setting noted.

Simple multiplication of the 540 dial frequency by the harmonic number yields the unknown frequency to within 0.5 per cent. Measuring the oscillator frequency on a Hewlett-Packard 524 series counter increases the accuracy of measurement on clean cw signals up to 1 part in 10^7. Model P932A's maximum input power is 100 mw and its minimum video output is 0.1 mv rms with 0 dbm input.

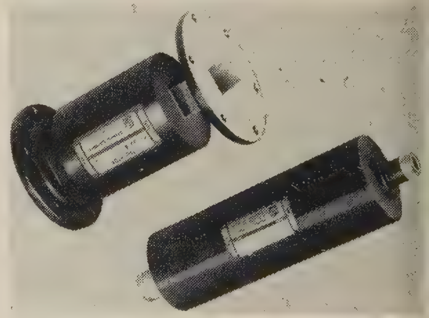
The other harmonic mixer, Model 934A, operates from 1 to 12.4 kmc and extends the range of the Hewlett-Packard 540A transfer oscillator from 5 kmc to 12.4 kmc. The 934A offers the same advantages as the P932A, including the fixed tuned feature eliminating tedious adjustment. Its maximum input power is 100 mw, and its typical sensitivity is —45 dbm at the mid-range points.

The Model P932A is priced at $250 and is currently available for delivery from stock.

Circle Reader Service Card 126

—*mwj*—

NEW CASWELL TEMPERATURE - COMPENSATED FERRITE ISOLATORS AVAILABLE



Temperature-compensated ferrite isolators in both waveguide and coaxial types are now available from stock at Caswell Electronics Corp., San Jose, Cal. These new isolators are designed for difficult operating environments such as encountered in aircraft and military applications. By their use, klystron and magnetron pulling and long line effects can be greatly reduced without concern for environmental operating temperature.

Compensation is achieved by a temperature-sensitive shunt which maintains the isolator at optimum performance over a very wide temperature range. Microwave characteristics remain essentially constant. Compensating mechanism is simple, highly reliable and does not add materially to unit selling price.

Typical specifications are: operating frequency — Several bands within 1120 to 12,400 mc range . . . isolation up to 40

. . . insertion loss of 0.5 db to 1.0 db . finished in attractive, dark green ed enamel. Mating surfaces are silver ed by a special process which minis tarnishing. Isolators can be supplied ruggedized mounting brackets.

ecification and price list for the come series are available without charge h manufacturer.

Circle Reader Service Card 127

—*mwj*—

LCO ANNOUNCES COMMERCIAL VAILABILITY OF MICROWAVE MADT'S

hilco Corp. Philadelphia, Pa., has be- marketing microwave coaxial MADT cro-alloy diffused-base) transistors in neering quantities at $125.00 each.

ccording to Dr. C. G. Thornton, director of semiconductor research and developat the firm's Lansdale Division.

he devices typically have a power gain db when operating into a cavity under hed neutralized conditions at 1000 mc. his frequency it is possible to obtain 10 mw of output power. At 200 mc units provide a gain of 22 db with a db noise figure."

Actually," Dr. Thornton continued, "the emely low collector capacitance (typical-16 micromicrofarads) obviates the need neutralization in most high frequency lications."

he package is a hermetically sealed xial type with holder matched for direct rtion into a 50 ohm co-axial network.

he packaging technique makes possible design of transistors as integral parts distributed transmission line networks, a manner similar to microwave mixer des. The absence of leads and other pped capacities lead to more uniform F amplifier performance in lumped uits as well as in coaxial systems.

Applications of Philco's coaxial ADT's include:

1. low noise amplifier at frequencies between 200 and 600 mc.
2. power amplifier for frequencies between 300 and 1000 mc.
3. local oscillator up to 2000 mc.

Additional information can be obtained m firm.

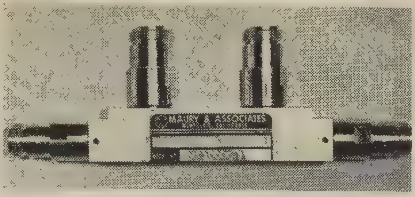
Circle Reader Service Card 128

—*mwj*—

IMPROVED SERIES OF DUAL DIRECTIONAL COUPLERS INTRODUCED

Maury & Associates, Montclair, Cal., has ently introduced an improved series of al directional couplers for very broadband plications. Available with either type N type C connectors, the units feature low VSWR, high directivity and high power handling capacity.

Specifications for the couplers are as follows: frequency range: 100 to 1000 mc; coupling at 100 mc: 30 db; coupling at 1000 mc: 12.5 db; VSWR-primary arm: 1.15 max.; VSWR-secondary arm: 1.20 max.; directivity: 20 db min.; and power capability: 500 watts cw.



The compact and rugged couplers are made of aluminum and are not affected by temperature or humidity changes.

In addition to the standard models described above, couplers with type BNC and type TNC connectors, as well as units with terminated secondary arms are available.

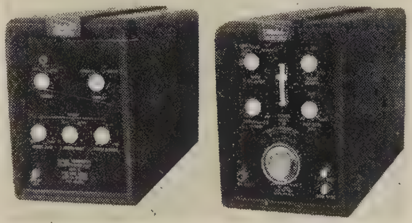
Circle Reader Service Card 129

—*mwj*—

NEW SIGNAL GENERATORS FROM MELABS AVAILABLE

A series of swept signal generators providing a constant power output over the entire frequency band is now available from Melabs, Inc., Palo Alto, Cal.

The series of electronically tuned generators includes five units covering, respectively, the L, S, C, X and Ku band frequencies (1 to 18 kmc). A common power and sweep supply (Melabs Model SGO-2, can be used with any of the units. All five generators are compatible with Melabs' radiometer and panoramic display unit, and the addition of a receiver box creates a swept receiver or signal frequency analyzer.



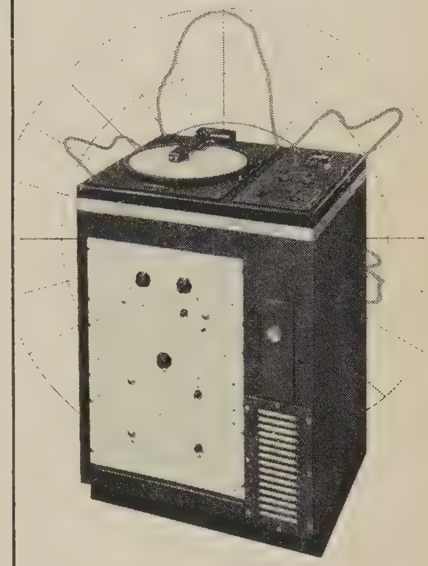
Specifications for a typical unit (Model SGS-2, S-Band) includes a power output which is constant to within 1 db over the entire band. The frequency/time characteristic, when sweeping, is linear within ±4 per cent. The whole, or any sector of the 2-4 kmc band, can be swept at any rate between 0.3 and 30 cps. For C.W. operation, or during sweeping, the full unregulated power of the BWO tube is available and can be manually controlled and externally modulated.

Prices of the new signal generators vary according to the frequency band and range from $2,300 (S-Band) to $4,500 (Ku-Band). Price of the Model SGO-2 common power supply is $900.

Circle Reader Service Card 130

(Continued on page 100)

POLAR PATTERN RECORDING SYSTEM



Measures Antenna Radiation Patterns

AIL's Type 116R Polar Pattern recording system precisely records directional characteristics of electromagnetic, acoustic, thermal, atomic, and light radiation patterns. It traces, in polar coordinates, a continuous inked plot of input voltage vs angular position.

Precision performance is assured by low internal noise, high sensitivity, accurate turntable drive and exact pen response.

Available accessories include a new automatic relative power computer and a square root amplifier.

Price: $3100.00

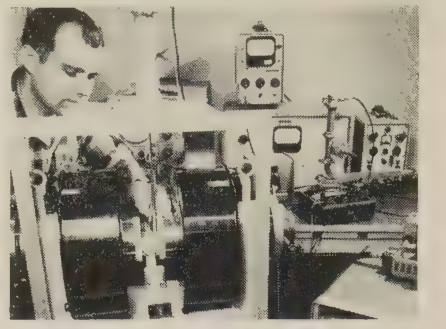
Write for details.

AIRBORNE INSTRUMENTS LABORATORY
DEER PARK, LONG ISLAND, NEW YORK
A DIVISION OF CUTLER-HAMMER, INC.

Circle Reader Service Card 59

(Continued from page 99)

MOTOROLA OFFERS TWO NEW FERRITE MATERIALS



Two recently developed ferromagnetic materials, completing a series of magnesium-manganese-aluminum ferrites, are now available to designers of isolators, circulators, duplexers and other microwave devices, according to Donald L. Fresh, manager of the Solid State Materials Laboratory, Scottsdale, Ariz.

These latest developments, Motorola Types M-092 and M-112 microwave ferrites, complete a family of four ferrite materials designed for general non-reciprocal device applications. Together with earlier Motorola Types M-022 and M-032 ferrites, the combined group offers the microwave device engineer an expanded selection of ferromagnetic characteristics in a ferrite system which has found wide general acceptance.

Now rounding out its second year of operation, the Motorola Solid State Materials Laboratory has developed and produ a most comprehensive line of microw ferrite materials. Its products include n ferrites and garnets covering the comp spectrum from UHF to K-band with l medium and high power handling capa ties. End items using these materials incl frequency doublers, mixers, limiters, ph shifters, resonance isolators, parame amplifiers, fast-acting, broad-band switc isolators, circulators and others.

Complete technical data applicable to latest two material developments are c tained in Motorola Technical Data Sh TDS-617 and TDS-618, available upon quest. Data on other materials as well consultation and recommendations for dev application is also available.

Circle Reader Service Card 131

—mwj—

AIRTRON INTRODUCES NEW LIGHTWEIGHT HIGH POWER LOA

A new 11-pound dummy load th dissipates 4.5 kw of average power a 3200 kw of peak power without liq cooling has been introduced for use w S-band radar by Airtron, Inc., Los An les, Cal., a division of Litton Industries.

Designated No. 890375, the dum load measures 14 inches long, 4 7/8 inc wide and 6 3/8 inches high. It is co patible with the RG-75U waveguide a

(Continued on page 104)

STODDART

COAXIAL ATTENUATORS AND TERMINATIONS

made with Stoddart Film resistors for highly accurate and stable resistive values from dc to 3000 mc.

2, 6 and 10-position
TURRET ATTENUATORS
with simple "PULL-TURN-PUSH" operation, small and rugged.

Protected under Stoddart Patents

ATTENUATOR PADS

Available in any conceivable combination of male and female Type C and Type N connectors. Maximum length of 3" for any attenuation value.
GENERAL SPECIFICATIONS
VSWR: Less than 1.2 to 3000 mc.
Characteristic Impedance: 50 ohms.
Attenuation Value: Any value from 0 db to 60 db including fractional values.
Accuracy: ±0.5 db; values above 50 db have rated accuracy of attenuation through 1000 mc only.
Power Rating: 1.0 watt sine wave.

COAXIAL TERMINATIONS

Small-stable-50 or 70 ohms

½-Watt: 50 ohms impedance, TNC or BNC connectors, dc to 1000 mc, VSWR less than 1.2.

1-Watt: 50 ohms impedance, dc to 3000 mc or dc to 7000 mc, Type N or Type C connectors, male or female; VSWR less than 1.2, 70 ohm, Type N, male or female terminations available.

Fast delivery on all items.
Send for complete literature.

STODDART
AIRCRAFT RADIO CO., INC.
6644 Santa Monica Blvd., Hollywood 38, Calif.
HOllywood 4-9292

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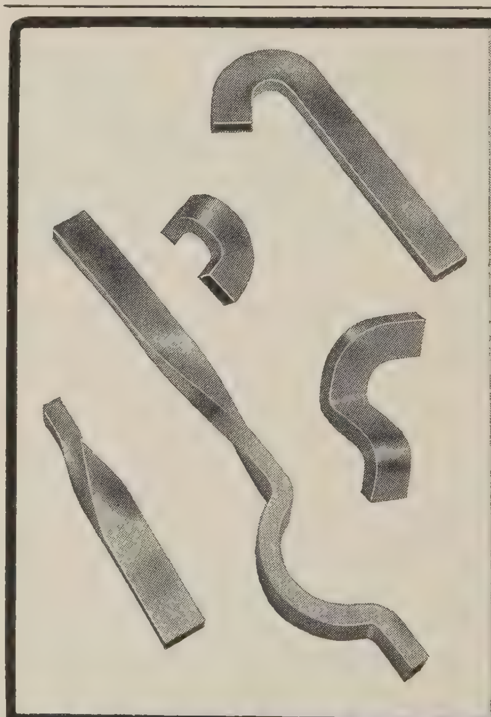

WAVEGUIDE

SPECIALISTS IN CLOSE TOLERANCE BENDING AND FORMING

INTASPACE CORP.
135 ORANGE ST., BLOOMFIELD, N. J.
PIlgrim 8-4700

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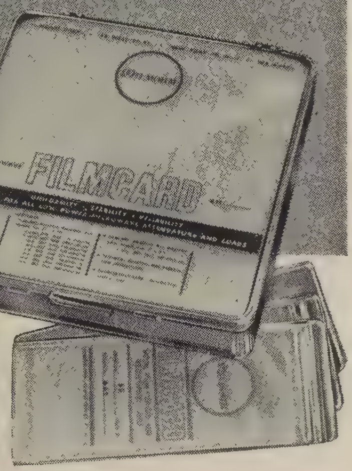
special introductory offer!

NEW LABOR-SAVING, MONEY-SAVING FILMOHM

FILMCARD

KIT FOR MICROWAVE APPLICATIONS



$40

Here in one compact, low-cost Kit is a practical assortment of precision-made, high stability microwave resistance material in easy-to-use form. Recommended for all applications requiring accurate and reproducible dissipation at low R. F. power, FILMOHM Resistance Cards may be punched, drilled, sheared, machined or sanded to suit your needs. Ideal for use as microwave attenuators and terminations, FILMCARDS are also THE proven material for directional coupler loads, isolation and impedance matching, protection of crystals and mode suppressors.

HERE'S WHAT YOU GET —

11 metal film Resistance Cards, 2½" x 5⅝" and one metallized mica Resistance Card, 2" x 2½"; plus fabrication instructions and technical bulletins.

FILMCARD FEATURES —

- MEETS MIL-P-18177 SPECIFICATIONS
- RESISTANCE RANGE AVAILABLE: 25 to 750 ohms/sq.
- STANDARD VALUES AVAILABLE: 50, 100, 125, 150, 180, 200, 300, 377, 400 and 500 ohms.
- RESISTANCE TOLERANCE PER SQ.: ± 10% standard.
- ELECTRICAL UNIFORMITY GUARANTEED
- DIMENSIONAL STABILITY

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48 WEST 25TH STREET • NEW YORK 10, N. Y.

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NEW SEMICONDUCTOR MOUNTS BRIDGE DESIGN GAP in microwave circuits!

TRI-PLATE MODULE
MODEL MX16
SANDERS ASSOCIATES, INC
NASHUA NEW HAMPSHIRE
f_S
f_I

Mounts Available To Fit:
TUNNEL DIODES
VARACTORS
MICROWAVE TRANSISTORS
MINIATURE DIODES
FAST-SWITCHING TRANSISTORS

MODULAR SANDERS TRI-PLATE® MOUNTS NOW AVAILABLE FOR ADVANCED SEMICONDUCTORS

This new Sanders strip transmission line development allows you t design the most advanced semiconductors into such application as parametric amplifiers, harmonic generators, and transisto circuits.

Sanders Semiconductor Mounts are an important addition to th present line of on-the-shelf Tri-Plate strip transmission module . . . and now permit designers to breadboard *almost any* microwave circuit in a matter of minutes. For complete specification prices and delivery schedules on Semiconductor Mounts or standard Tri-Plate module kits write today.

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Product Manager, Microwave Products Dept., NASHUA, NEW HAMPSHIR

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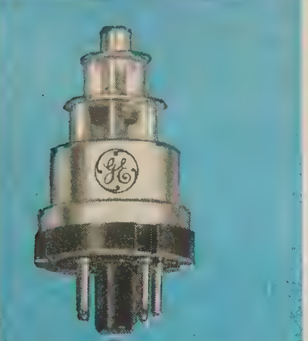


GL-2C40A

GL-2C43

Z-5033

GL-6442

LIGHTHOUSE – GLASS

ypical output is 75 mw as a CW scillator at 3370 mc. Greater out-ut obtainable at lower frequencies. eatures include low interelectrode apacitances, low lead inductance nd low loss. Performance-proved nd economy-priced. Height is 9/16".

ypical applications are as a Class RF amplifier, a Class C CW oscil-ator and a plate-pulsed oscillator.

Typical output is 1.75 kw as a pulsed oscillator at 3370 mc. Greater output obtainable at lower frequencies. This single-ended tube features low impedance and is 2 11/16" high. Like the GL-2C40A, this tube is economy-priced.

Typical applications are as a Class C RF amplifier, a Class C CW oscillator, and a plate-pulsed oscillator.

A long-life version of type GL-2C43. The objective for this tube is 15,000 hours at 1000 mc. While designated developmental until this objective is proved, the tube is available from production. Like the GL-2C43, it is single-ended, features low impedance, and is 2 11/16" high.

It is designed to serve as a Class C CW oscillator.

LIGHTHOUSE

A general purpose, medium-mu JAN triode, this tube is especially suited to pulsed operation up to approximately 5000 mc. It gives 2 kw useful pulsed power output at 3500 mc, and approximately 500 watts at 5000 mc. Height is 2 39/64".

Typical applications include Class C amplifier, oscillator, mixer and amplifier in both CW and pulsed service.

TO MEET ALL APPLICATION REQUIREMENTS . . .

General Electric Now Offers You Industry's

LIGHTHOUSE – MINIATURE CERAMIC

GL-6299

GL-7391

GL-7644

Z-5435

tra-reliable for high-gain, low-ise applications to 3000 mc. Noise gure of 4.3 db and gain of 18.5 at 450 mc. Operational warranty 1000 hours. This UHF-SHF tube s high shock and vibration re-tance and is conduction-cooled. is tube and its derivatives are ly 1" high.

application is as a Class A_1 RF nplifier.

This is a Class C version of tube type GL-6299. It operates up to 6000 mc. Its power output is 65 mw at 5400 mc. Moreover, its power output is greater than 0.5 watts at 500 mc. This new, metal-ceramic UHF-SHF low-power triode features conduction cooling and has a grounded grid.

Principal application is as a Class C CW oscillator.

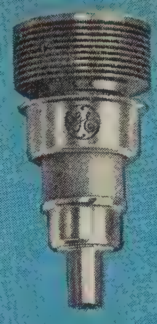
This derivative of type GL-6299 operates up to 3000 mc, and is notable for its high spike resistance capabilities. The tube is unilaterally interchangeable with type GL-6299. Only recently announced, this sturdy, UHF, low-noise and low-power triode features a grounded grid and conduction cooling.

It is especially suitable for application as a Class A_1 RF amplifier.

The frequency range for this tube is up to approximately 3000 mc. It is a low-noise, high-gain UHF triode, similar in all respects to the GL-6299 except that it is designed with an isolated heater. It features a grounded grid and is conduction-cooled.

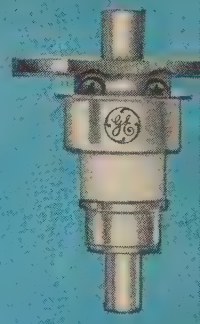
It is recommended for application as a Class A_1 RF amplifier.

GL-6771



GL-6897

Z-5387



Z-5099A

ERAMIC

high-gain, high-mu, closed-spaced
ode with useful output in excess
500 mw at 4000 mc, CW and
der pulsed conditions. Several
ndred mw obtainable at 6000 mc.
atures low interelectrode capaci-
nces and rugged planar construc-
n. Height is 2 39/64".

commended for low and inter-
diate level amplifier and multi-
er applications because of its ex-
ptional gain.

This version of the 2C39 family is especially suited to high-frequency operation. Has 100 watt anode dissipation. Gives 30% efficiency and 10 db gain at 1860 mc and 600 volts. Height is 2 11/16". Efficient pulse performance to 3000 mc.

Notable for consistent high-gain performance, resulting from closely controlled manufacturing and processing tolerances and thorough characteristic testing in accordance with MIL-E-1/1037B.

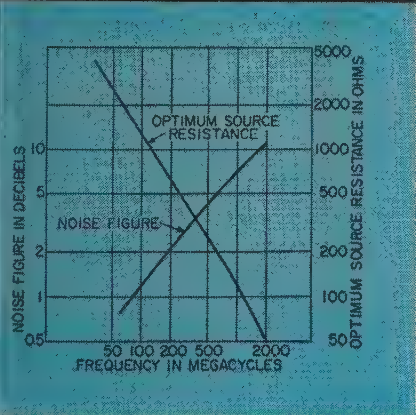
This tube is a finless version of type GL-6897 for applications where there are space limitations, and the full plate dissipation of the GL-6897 is not required. Height is 2¾".

Possible applications include pulsed airborne navigational equipment and airborne communications. The tube is operable as a Class C pulsed or CW amplifier, oscillator, and frequency multiplier.

A conduction-cooled version of
GL-6897, for grounded-grid
C power amplifiers, oscillator
frequency-multiplier circuits u
2500 mc. 35 watts plate dissip
readily obtainable. Features
rugged disc-seal construction as
GL-6897. Gives consistent high
formance. Height is 2⅝".

Designed specifically for missile
other non-air-cooled applicat

Most Complete Line of Microwave Triodes



Calculated Noise Performance for Noise-matched, Grid-return Circuit Operation, Input Circuit Losses Neglected.

GL-6299 • GL-7644 • Z-5435

Operating Conditions

$E_f = 6.3$ volts

$E_c = 0$ volts

$E_b/I_b = 10$ milliamperes

Illustrated on these two pages are just twelve of the more tha
twenty microwave triode types General Electric now offers . .
industry's most complete line. Rugged, versatile G-E "lighthouse
triodes are now available for all types of microwave communica
tion, navigation, identification and radar equipment . . . for a
ground, sea and airborne applications.

For more information on General Electric's complete line o
microwave triodes, and for competent application engineering as
sistance, contact your General Electric Power Tube Sales Office

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Newtonville, Massachusetts
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SYRACUSE
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Syracuse, New York
Tel.: HArrison 2-1030

SCHENECTADY
Building 267
Schenectady 5, New York
Tel.: FRanklin 4-2211
Ext.: 5-3433

EASTERN
200 Main Avenue
Clifton, New Jersey
Tel.: GRegory 3-6387
Dial direct from N.Y.C.
WIsconsin 7-4065-6-7-8

CENTRAL
3800 No. Milwaukee Avenue
Chicago 41, Illinois
Tel.: SPring 7-1600

DAYTON
118 West First Street
Dayton 2, Ohio
Tel.: BAldwin 3-7151

WESTERN
11840 West Olympic Blv
Los Angeles 64, Californi
Tel.: GRanite 9-7765

WASHINGTON
Wyatt Bldg.—Room 131
777—14th Street, N. W.
Washington, D. C.
Tel.: EXecutive 3-3600

POWER TUBE DEPARTMENT

GENERAL ELECTRIC

265-01-8481-28

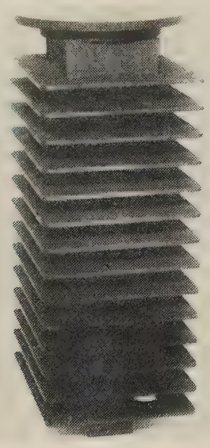
Circle Reader Service Card 63

New Products

(Continued from page 100)

can be used with any radar operating in the range from 2600 to 3950 megacycles to dissipate microwave energy when the radar is not transmitting.

The Model 890375 is smaller and lighter than units of equivalent rating and is designed for use under extreme conditions.



Use of inert, high-temperature silicon carbide as the absorptive element minimizes water absorption, increases stability and lengthens trouble-free life. Liquid-cooled versions are also available to dissipate significantly higher powers.

Smaller and lighter models of dummy loads were previously introduced by Airtron for lower power applications. The entire line of Airtron high-power dummy loads was shown at WESCON Aug. 23-26 in Los Angeles.

Further information can be obtained from the firm.

Circle Reader Service Card 132

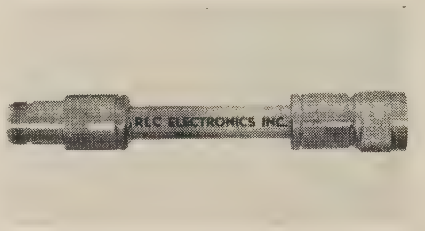
—mwj—

NEW LINE OF MINIATURIZED PRECISION LOW PASS FILTERS ANNOUNCED

A new line of miniaturized precision coaxial low pass filters has been announced by RLC Electronics, Inc., Mamaroneck, N. Y. These small rugged coaxial filters, Model F-30 can be supplied with cut-off frequencies of 100 mc to 10,000 mc.

Impedance matching techniques and transforming sections combined with precision fabrication of coaxial assemblies allow VSWR of no more than 1.2 in the pass band. A maximum insertion loss of 0.2 db is also maintained in the pass band.

Sharp cut-off and high rejection in the stop band are assured by multi-section design. The stop band rejection of 60 d occurs from 1.35 to 5 fc.



These units, whose power rating is 10 watts, can be supplied with type N, C, o TNC connectors. The overall length depending upon cut-off frequency is fro 4¾ inches to 12¼ inches.

Model F-30 type of filters is but one o a comprehensive line of coaxial low an high pass filters of a miniature and subminiature type. Special filters requirin different cut-off frequencies, sharper stop band characteristics, higher power levels different sizes and finishes can also b supplied.

RLC also produces a wide range of attenuators and terminations. Complete information about Model F-30 filters an other items is available.

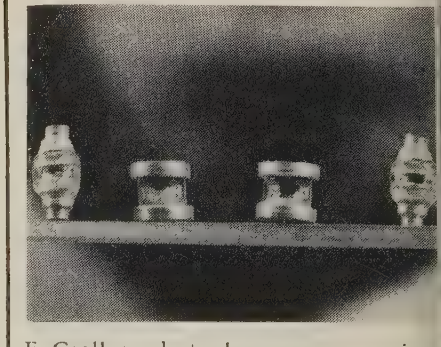
Circle Reader Service Card 133

—mwj—

SYLVANIA ANNOUNCES MICROMINIATURE "VARACTOR" DIODE SERIES

Two series of microminiature silico mesa diodes, one-eighth of an inch i length and width, have been develope for manufacturers of advanced electroni equipment including countermeasure systems and high speed computers, b Sylvania Electric Products Inc., Wobur Mass.

Known as microminiature "varactors or amplifying diodes, the new microwav components (Series D-4140A to E an D-4141A to E) are hermetically seale in Sylvania-designed cylindrical glas cases which "make them especially desirable in printed circuit cavity and strip transmission lines," according to Marvi E. Groll, product sales manager — microwave diodes of Sylvania's Semiconducto division.



The D-4140 Series (0.105-inches (i diameter by 0.235-inches in length) use a package with gold-plated precision axia mounting studs. Series D-4141 (0.125 X 0.125-inches) is designed with gold plated flange-type end caps. Both serie are electrically similar to their large counterparts (Series D-4075) and ar capable of operation up to 100-degree Centigrade with cut-off frequencies up t 70 kmc. The D-4140 package is designe for traveling wave structure parametri amplifiers, Mr. Groll said.

Circle Reader Service Card 134

—mwj—

LIECO WAVEGUIDE SWITCHES

LIECO INC.
29-E3-000
WAVEGUIDE SWITCH

A COMPLETE LINE
OF CUSTOM-MADE
"STOCK" UNITS

- Position indicator light switches integral to the waveguide switch.
- Automatic interlock switches available.
- Operates with or without a holding current.
- Any desired voltage.
- Engineered to suit your package problem at prices competitive with "shelf" units.
- Switching available in either plane, SPDT, DPDT, or Single Pole Multithrow.
- Fully meets MIL-T-5422.
- Covers entire waveguide band.
- Handles full waveguide power.
- Maximum VSWR 1.1:1.
- Extremely high isolation.
- Rapid switch return.
- Extremely low insertion loss.
- Continuous duty operation.
- Pressurized.
- All sizes from RG96 thru WR-2100 Waveguide.

Special Power Supplies also available—designed to your needs.
Submit your problems for our solution.

LIECO INC.
EILEEN WAY • SYOSSET, L.I., N.Y.
Phone WAlnut 1-6300

Circle Reader Service Card 64

dustry News

ntinued from page 81)

MELPAR AWARDED ELECTRONICS CONTRACTS

he System Analysis groups of Melpar, ., Falls Church, Va., have been awarded ontract to determine trends for future orne molecular electronics techniques the Wright Air Development Division the Air Force Research and Development Command.

he Northern Virginia firm will make study of airborne electronics within raft, missiles, and other airborne vеles to determine the frequency, distriion, similarities and individual chareristics of electronic equipment and uit functions within existing and proed airborne electronic subsystems.

nder another contract, Melpar's Aped Science Division in Watertown, ss., will evaluate the capability of the lpar-developed and fabricated T-12 namic Tester to check out the ground dance portion of the Nike Hercules face-to-air range system, for the Frank- Arsenal of the U. S. Army Ordnance trict, Philadelphia, Pa.

SD will adapt two T-12's to improve ance, prepare programmed tapes and feasibility demonstrations prior to ing a field test and data reduction gram.

elpar, an electronics firm in the thern Virginia area, is a subsidiary Westinghouse Air Brake Company.

—*mwj*—

TRANSCO PRODUCTS APPOINTS UNDERBERGER

George M. Underberger has been appointed Project Engineer at Transco Products Inc., Los Angeles, Cal., according to Marshall Sawyer, Sr., president.

In this capacity, Mr. Underberger will be responsible for the development and expansion of Transco's line of microwave components and sub-systems.

Prior to joining Transco, Mr. Underberger was with the Kearfott Division of General Precision, Inc. as Manager of the Systems Engineering Laboratory. He has over 10 years of experience in the micro wave field.

He is retiring chairman of the Los Angeles Chapter of the Professional Group on Microwave Theory and Techniques and is a Senior Member of the I. R. E.

—*mwj*—

ANTENNA LECTURE SERIES SLATED

The Washington, D. C. IRE PGMTT and PGAP are sponsoring a repeat performance of the Antenna Theory and Techniques lecture series presented by the New York IRE PGMTT in the Spring of 1960. Beginning on Tuesday, October 11, 1960, and on alternate weeks thereafter, a series of five tutorial lectures on the subject "Microwave Theory and Techniques" will be offered.

Dr. Henry Jasik of Jasik Labs, Inc., will start Session 1 off on October 11, 1960 with "Fundamentals of Antennas." Session 2 will be on October 25, 1960, with R. L. Mattingly of Bell Telephone Laboratories speaking on "Reflectors as Antennas." K. S. Kelleher of Aero Geo Astro Corp. will be at Session 3 on November 10, 1960 to speak on "Lens Structures and Artificial Dielectrics." Dr. A. A. Oliner of Polytechnic Institute of Brooklyn will talk on "Principles of Traveling-Wave Antennas" at Session 4 on November 22, 1960. "Microwave Measurement Techniques" by Dr. Thomas E. Tice of Ohio State University will conclude the series on December 6, 1960 (Session 5).

The lectures will be held in the East

(Continued on page 106)

SCHMELZLE HEADS MICROPHASE SALES DEPARTMENT

The appointment of Carl W. Schmelzle to the position of gineering sales manager, was recently announced by Microase Corp., Greenwich, Conn., manufacturers of microwave nponents. The Corporation specializes in coaxial as well as veguide filters, multiplexing networks, cavity preselectors, solid-state devices.

Mr. Schmelzle, formerly a group engineer with Philco Corp., vernment and Industrial Division, has extensive experience the microwave field. In addition to his work in low-power , and miniature transistorized equipment, he was responsible the design and development of solid-state S-Band microve receivers for satellite applications.

In his new capacity, Mr. Schmelzle will be responsible for the rdination of the sales and the promotion of all Microphase ducts.

—*mwj*—

LFE EXPANDS

Laboratory For Electronics, Inc., has acquired 100,000 uare feet of plant and office space adjacent to its present mmonwealth Avenue headquarters in Boston, Mass. An eightr lease has been signed.

Intended to provide additional floor space, it is anticipated t certain departments now in the headquarters building will relocated by December.

LFE departments and divisions located in other sections of tropolitan Boston will move into the new building when a modeling program has been completed.

In addition to new lighting, heating and power distribution uipment, plans call for a "bridge" to be constructed connecting third floor of the new building with the third floor of the adquarters building.

When consolidated, LFE facilities will total approximately 0,000 square feet, including a flight test center at nearby dford Airport.

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THE FINEST QUALITY BRASS AND ALUMINUM STANDARD WAVEGUIDE FLANGES in stock at Formcraft—all precision made to military standards. For rigid and flexible waveguides.

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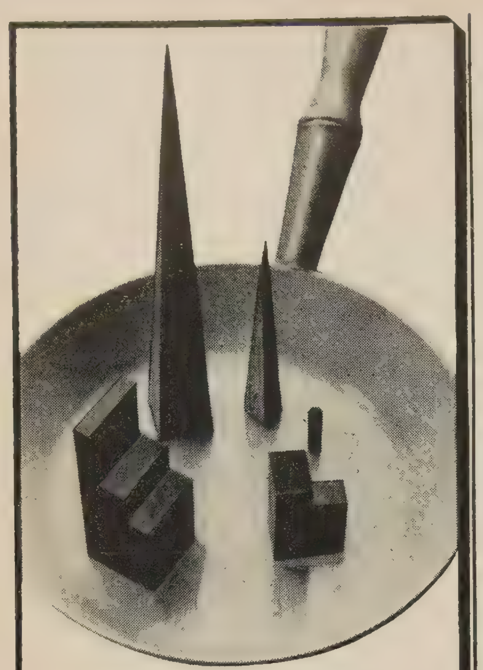

NEW CMA-415 PERMEABLE DIELECTRIC MAINTAINS THERMAL STABILITY TO 400°F

Custom Components' new microwave absorber is ideal for advanced system applications. High attenuation... easily molded or machined to specific tolerances... prompt service and deliveries to match your needs.

CUSTOM COMPONENTS, inc.

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CApital 6-3404

(Continued from page 105)

Building lecture room at the National Bureau of Standards in Washington, D. C. Inquiries should be directed to the Lecture Series chairman, Benjamin Bernstein, Polytechnic Engineering Co., Silver Spring, Maryland. (JUniper 8-5441).

—mwj—

G. E. RECEIVES AWARD FOR PRODUCTION OF ADDITIONAL SEARCH RADARS

A $15,625,000 production contract for AN/FPS-24 Frequency Diversity Search Radars has been awarded to the General Electric Company's Heavy Military Electronics Department, Syracuse, N. Y., it was announced by Mr. John J. Farrell, Department general manager. The award was made by the Directorate of Procurement and Production, Rome Air Material Area, Griffiss AFB, Rome, New York.

"These new high power, long range search radars incorporate the most advanced signal processing circuits and techniques," Mr. Farrell said. They are designed to detect strategic, supersonic aircraft at longer ranges and higher altitudes than present-day search radars, despite the presence of interference and enemy countermeasures.

Under development since April 1956, the FPS-24 was designed for the Air Force by G-E in cooperation with the Air Research and Development Command's Rome Air Development Center at Griffiss AFB. It is part of a whole new family of air defense radars, which are known as Frequency Diversity radars. The prototype FPS-24 radar was installed at an Air Force site in Alabama last year for service testing and evaluation. When placed in operational use, the FPS-24 radar will supply information to the SAGE Continental Air Defense System.

The antenna system for the AN/FPS-24 is one of the world's largest rotating radar structures. Comprised of a reflector, pedestal and feedhorn erected on a fifty-foot boom, the antenna system measures 120 feet wide and 50 feet high, and weighs more than 135 tons (275,000 lbs)

The giant screen-like reflector, which focuses the high power radar frequen pulses transmitted by the FPS-24, mea ures 120 feet wide by 36 feet high a weighs 30 tons. Made up in 51 sectior the reflector screen and supporting back structure contains more than two mil (12,600 feet) of high strength aluminu and low temperature steel. It is mount on a ten-foot high rotating pedestal a proximately the size of three trail trucks parked in a "T".

Electronic equipment for the FPS-24 being manufactured at the Gener Electric Company plants in Syracus D. S. Kennedy and Co., of Coha sett, Mass. is building the antenna flectors, and McKiernan-Terry Cor Dover, N. J., is producing the a tenna pedestals. Approximately 15 small business firms and sub-contracto many from the central New York are are members of the General Electric i dustrial team supplying parts for t AN/FPS-24 radars.

—mwj—

GINSBERG NAMED BY LORAL

The appointment of Murray Ginsbe as chief engineer, development, was a nounced today by Loral Electronics Cor New York, N. Y.

Mr. Ginsberg will assume responsibili for technical coordination of all enginee ing development activities. A graduate NYU, he formerly held engineering ma agement positions with Republic Aviati Corp. and project engineering a advanced planning posts with t Weapons Systems Division of Wrig Air Development Center, USAF. Mr. Gin berg is a licensed professional engine and a senior member of the IRE.

Loral is a supplier of electronic syste and equipment for the Department Defense. Through subsidiary firms it a producer of electrical and electron components for industrial and commerci applications.

—mwj—

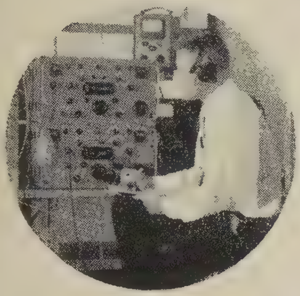
HARVARD APPOINTS WILLENBROCK ASSOCIATE DEA OF ENGINEERING

Dean Harvey Brooks announces the a pointment of Dr. F. Karl Willenbrock Associate Dean of Engineering a Applied Physics at Harvard Universit Cambridge, Mass.

Dr. Willenbrock, an expert in ele tronics, succeeds the late Professor Albe Haertlein, who died in June.

Dr. Willenbrock has been engaged research and teaching at Harvard sin 1950. Since 1952, he has been a lectur on Applied Physics and for the past fi years he has been associate director the Engineering and Applied Physi Laboratories. He has just completed ser ing as chairman of the Boston section the I.R.E.

—mwj—



pportunity

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at HRB-Singer for a Microwave Receiver Engineer to design and develop a number of microwave receivers. This engineer will be responsible for the design of pre-selectors, local oscillators, various types of mixers, RF filters, and wide band (octave) RF amplifiers. Position shows promise of considerable advancement.

Experience should include:

- MSEE or BSEE degree
- Three to five years experience in the field
- Experience in waveguide and coaxial component design for microwave receivers
- Familiarity with TWT and BWA techniques

HRB offers the opportunity to work on vital electronic problems; an attitude of research emphasizing freedom of expression; a location combining the cosmopolitan atmosphere of a city with the advantages of small-town living. Through the tuition-refund plan, employees are encouraged to pursue graduate study at the nearby Pennsylvania State University. Write in confidence to Personnel Director, Dept. M-1, HRB-Singer, Inc.

HRB-SINGER, INC.

Science Park, State College, Pa.
A SUBSIDIARY OF
THE SINGER MANUFACTURING CO.

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NEW LITERATURE

NEW STOKES BROCHURE PUBLISHED

Improving the dielectric efficiency of large distribution transformers, the armatures of generators and motors, ignition wiring systems, coils and capacitors, and components for radar and other electronic systems; and increasing the physical strength and reliability of metal castings of brass and bronze, aluminum, magnesium and other light metals, for such stressed structures as jet engine compressor housings and gear boxes — these are some of the principal current applications for vacuum impregnation, the advantages of which are presented in detail in the latest revised edition of a 16-page brochure on "Vacuum Impregnation" which has just been published by F. J. Stokes Corp., Philadelphia, Pa.

The brochure also describes the entire range of Stokes vacuum impregnating systems, with illustrations of a number of outstanding installations, and gives complete specifications for Stokes standard cylindrical and rectangular impregnating chambers and impregnant storage tanks.

Circle Reader Service Card 136

—mwj—

AERODYNAMIC AND RANDOM SIGNAL INSTRUMENTATION BOOKLET PUBLISHED

Flow Corp., Arlington, Mass., has published a four-page short-form catalog illustrating and providing information about its line of aerodynamic and random signal instruments. Included are hot wire anemometer systems and probes, a micromanometer, a static pressure probe and a random signal voltmeter and correlator.

Circle Reader Service Card 137

—mwj—

THERMISTOR PROBE BROCHURE RELEASED

Fenwal Electronics, Inc., Framingham, Mass., has released a new 8-page folder on their standard line of thermistor probes. It contains more than 50 outline drawings showing dimensions, and gives a description and primary use for each

Circle Reader Service Card 138

—mwj—

BOMAC RELEASES PRODUCT CATALOG

Bomac Laboratories, Inc., Beverly, Mass., has released a new product catalog. It contains specifications on over 600 microwave tubes and components including: TR, ATR, pre-TR tubes, shutters, reference cavities, crystal protectors, silicon diodes, magnetrons, klystrons, duplexers, pressurizing windows, noise source tubes, high frequency triode oscillators and surge protectors.

It also contains full information on how to order as well as a complete listing of Bomac's representatives.

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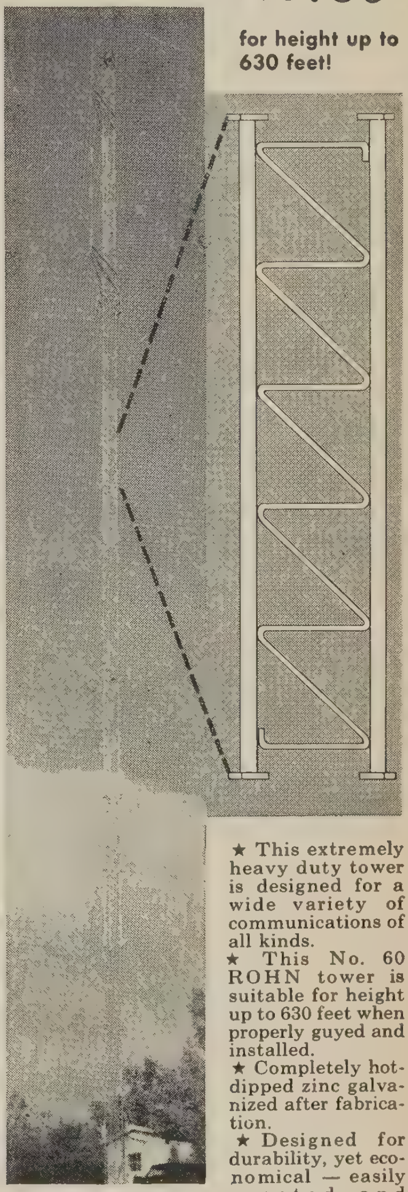
—mwj—

(Continued on page 108)

ROHN
COMMUNICATION
TOWER *No. 60*

for height up to 630 feet!



★ This extremely heavy duty tower is designed for a wide variety of communications of all kinds.
★ This No. 60 ROHN tower is suitable for height up to 630 feet when properly guyed and installed.
★ Completely hot-dipped zinc galvanized after fabrication.
★ Designed for durability, yet economical — easily erected and shipped. ROHN towers have excellent workmanship, construction and design. Each section is 10 feet in length.

Shown here is a ROHN No. 60 tower installed to a height of 200 feet with 3 five-foot side arms, mounting antenna for police radio communications.

FREE

Details and complete engineering specifications gladly sent on request. Also ROHN representatives are coast-to-coast to assist you.

Write-Phone-Wire Today!

ROHN *Manufacturing Co.*
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Peoria, Illinois
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"Pioneer Manufacturers of Towers of All Kinds"

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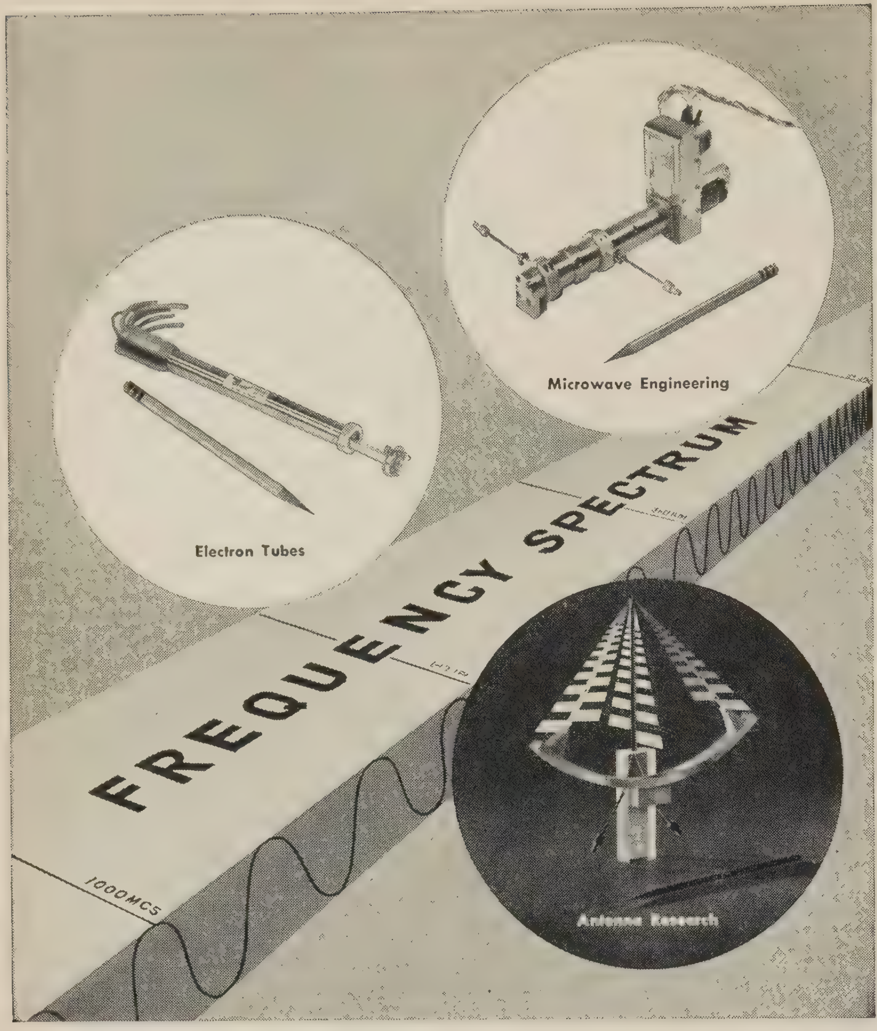

OPPORTUNITIES IN UHF AND MICROWAVE RESEARCH AND DEVELOPMENT

Never before has such high priority been given to microwave research and development . . . never before have the opportunities been so great in this field for the qualified engineer and scientist.

The Research Center of The Bendix Corporation—The RESEARCH LABORATORIES DIVISION—is expanding its programs in the UHF and microwave field to create interesting and challenging positions for qualified personnel.

Technical openings are now available in the following fields:

ANTENNA RESEARCH in electronic scanning, log periodic antennas, microwave optics.

MICROWAVE ENGINEERING—in ferrite devices, electronically controlled phase shifters, parametric amplifiers.

ELECTRON TUBE research in BWO and TWT from 1,000 to 150,000 mcs.

Investigate these opportunities *now*, where your technical competence and potentialities will receive full recognition in "Building Your Future with Bendix".

If interested, please write or wire A. Capsalis,
Research Laboratories Division, The Bendix Corporation,
Southfield, Michigan.

Research Laboratories Division
SOUTHFIELD, MICHIGAN

THE Bendix CORPORATION

New Literature

(*Continued from page 107*)

FACILITIES FOLDER ANNOUNCED

Antenna Systems, Inc., Hingham Industrial Center, Hingham, Mass., announce a four page file folder that briefly describe its areas of interest and capabilities fo designing and manufacturing antennas. I also gives brief biographical sketches an qualifications of the principals in the firm

Circle Reader Service Card 140

—*mwj*—

SYLVANIA TWT AND BWO CATALOG COMPLETED

A new catalog of traveling wave tube and backward-wave oscillators has bee made available by the Special Tube Operations of Sylvania Electric Products Inc. New York, N. Y.

The new catalog contains frequency gain, helix voltage and other data on 1 types of L, S, and X bands traveling-wav tubes with peak powers up to one kw Both permanent magnet and solenoid foc used types are included. Listed for th first time are two new S band periodi permanent magnet tubes, types TW-4002 and TW-956H, with temperature compensation from —54°C to above +71°C These tubes also feature special magneti shielding which makes possible smaller more compact equipment.

Among the new backward-wave oscillators described in the catalog is typ

MICROWAVE TUBE ENGINEERS
B.S. to Ph.D.

interested in research development or manufacturing are offered a stimulating atmosphere at Hughes Microwave Tube Division in Los Angeles.

Areas of specialization include:

- high-powered periodically-focused travelling-wave amplifiers
- lightweight low noise amplifiers for broad band receivers
- low drainage satellite communication tubes
- multielement phased array amplifiers

Responsibility is limited only by ability. For additional information or to arrange an interview appointment, please write, wire or call collect: **Mr. Don MacDowell, ORchard 0-1515, Extension 5792.**

HUGHES
MICROWAVE TUBE DIVISION
HUGHES AIRCRAFT CO.
11105 ANZA, LOS ANGELES 45, CALIFORNIA

V-1779, a PM focused tube designed CW or pulsed operation from 63 to kmc, as well as devices covering the S, and C bands, and the 18 to 41 kmc ion.

Circle Reader Service Card 141

—mwj—

MULTI-CONTACT CONNECTORS BROCHURE OFFERED

Connectors for every need are described a colorful, 12 page brochure offered by e Electro Mechanical Instrument Divi-on of Consolidated Electrodynamics orp., Pasadena, Cal., subsidiary of Bell Howell Co.

Photos and diagrams are used to scribe in detail all types of multi-con-t connectors and their applications.

Bulletin 4004B is available upon quest.

Circle Reader Service Card 142

—mwj—

BULLETIN DESCRIBES UHF WIDEBAND POWER OSCILLATOR

A new technical bulletin on UHF wide-nd power oscillator model 1141, con-ning complete specifications, perform-ce data and application notes, has been de available by the W. L. Maxon Corp., struments Division.

This model features unusually high wer out at various frequencies — 200 to 0mc 40 watts, 400 to 1050mc 25 watts, 0 to 2500mc 10 watts.

Circle Reader Service Card 143

—mwj—

NEW LUCAS-MILHAUPT BRAZING PREFORMS BOOKLET AVAILABLE

A new booklet on designing for alloy reforms by Lucas-Milhaupt Engineering o., Cudahy, Wis., manufacturer of pre-orms, is now ready for distribution.

Included in the 20 pages are compari-ons of preform versus hand feeding; e applications of round wire rings, flat ire rings, mandrel wound rings and the atented no-tangle notch-coil rings. It also eals extensively with edgewound and lanked washers and the completely new urved washers and shims. Many types of reforms and their applications are illus-rated.

Of special significance is the complete aterial selection chart that shows the arious gold, silver, aluminum and soft older alloys — their compositions, the elting points, the flow points and their eneral characteristics.

Considerable descriptive matter is de-oted to the comparatively new aluminum razing preform processes.

The importance of flux, types of fluxes nd the methods of flux application is utlined.

A section is devoted to the use of pre-orms in the electronics industry — the tocking and immediate availability of reforms in a wide variety of sizes of the ilver-copper eutectic . . . the silver-copper-ndium alloys, silver-copper-tin alloys, ne silver and OFHC copper.

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IMMEDIATE OPENING FOR

MICROWAVE SECTION HEAD

Here is an outstanding opportunity for an engineer with heavy experience in original design to head up a dynamic R & D group working on:

- CRYSTAL SWITCHES
- CRYSTAL DETECTOR MOUNTS
- MICROWAVE FILTERS
- OTHER SOLID STATE DEVICES

See our Microwave ad . . . page 12

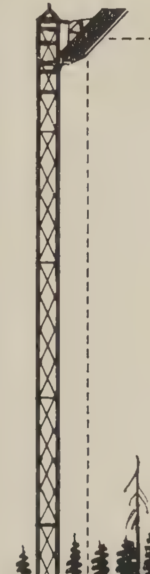
other AEL activities include:

ANTENNAS • COMMUNICATIONS • MEDICAL ELECTRONICS

This opening is created by AEL's dynamic growth and results from long range planning. Restricted stock option available.

For further information call Philadelphia collect (WAlnut 5-8785) or write Mr. John W. Cox.

AMERICAN ELECTRONIC LABORATORIES, INC.
121 N. 7th Street, Philadelphia 6, Pa.



Microwave Engineers

Lenkurt Electric Co., a leading manufacturer of high performance carrier telephone, microwave and data transmission equipment, has immediate openings for senior microwave engineers in the development of microwave radio systems for multi-channel telephone service. Experience in video amplifier and broad band IF circuits, microwave test and design techniques and an understanding of semi-conductor applications in the microwave region is desirable. 5 - 10 years experience with a BS degree, or higher required. Top salary, liberal fringe benefits, including a stock purchase plan. Modern engineering labs located on the beautiful San Francisco peninsula.

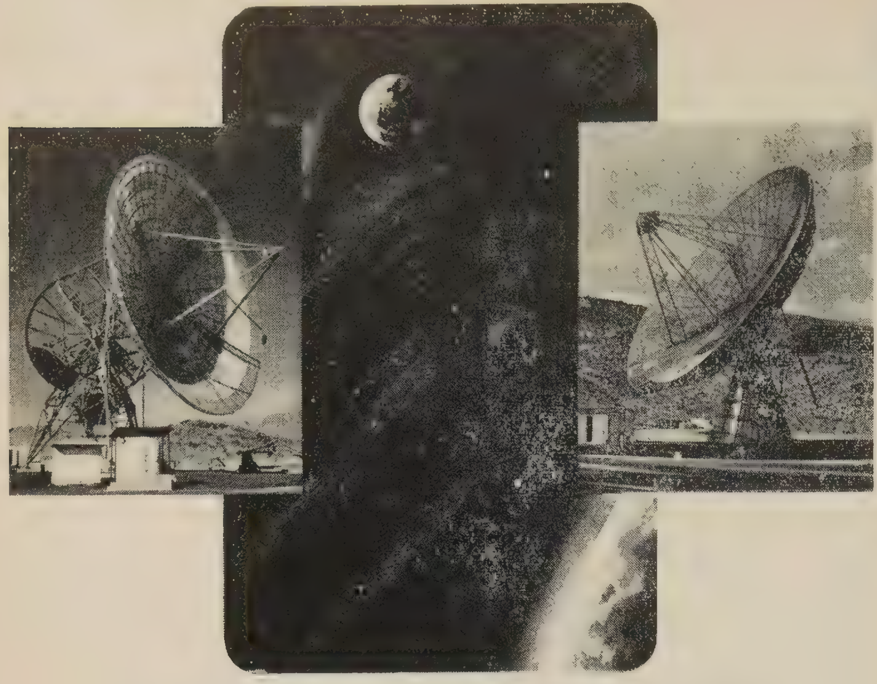
Also other Communications Development Engineering positions available. For interested engineers, facilities in Vancouver, B.C., Canada, offer many opportunities.

Send resume or call collect LY 1-8461.

E. JACK SHANNAHAN
Employment Manager

Lenkurt ELECTRIC CO., INC.
San Carlos, California
a subsidiary of General Telephone & Electronics

LUNAR and PLANETARY COMMUNICATION



SENIOR RESEARCH SPECIALISTS

New opportunities involving advanced research and development projects are now open at JPL in the Laboratory's Telecommunications Division for engineers and scientists capable of assuming a high level of technical responsibility.

SOME SPECIFIC OPENINGS IMMEDIATELY AVAILABLE

Communication Specialists
Execution of RF tracking and communication system projects.

Radio Research Engineers
Design of advanced RF transmitter / receiver equipment.

Antenna Specialists
Analysis, design and evaluation of giant Antenna Structures and Servo Systems.

Research Scientists
Digital data and control system analysis and synthesis.

Mathematicians or Communication System Analysts
Analog and Digital system analysis.
Noise, coding, information theory.
Linear and non-linear filter theory.

Several openings also exist for supervisors of Research and Advanced Development Projects performed by industry for JPL.

CALIFORNIA INSTITUTE OF TECHNOLOGY
JET PROPULSION LABORATORY
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Barnstead Still & Sterilizer Co. . .
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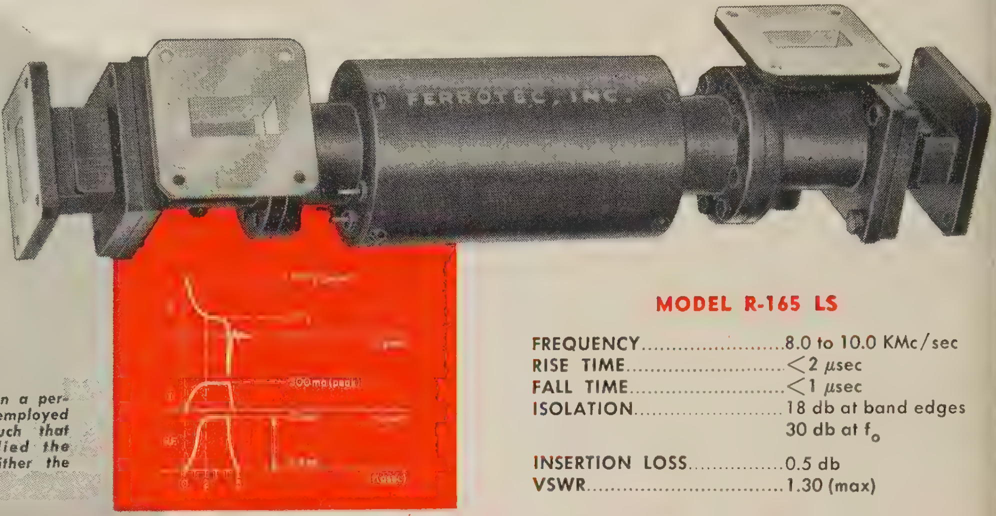
MICROWAVE FERRITE CIRCULATORS

FERROTEC's Model R-165 LS is the first high performance X_S broadband fast ferrite switch of its kind (22 percent band without current adjustment).

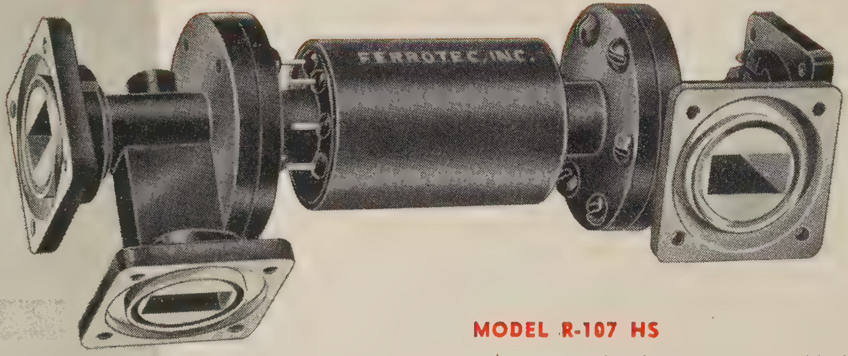
**In the waveforms shown a permanent magnet was employed to bias the switch such that with no current applied the switch would be in either the ON or OFF position.*



MODEL R-165 LS

FREQUENCY	8.0 to 10.0 KMc/sec
RISE TIME	<2 µsec
FALL TIME	<1 µsec
ISOLATION	18 db at band edges 30 db at f_o
INSERTION LOSS	0.5 db
VSWR	1.30 (max)

Model R-107 HS K_u band high power fast ferrite switch permits two microwave antennas to be time-shared by a common transmitter and receiver.



MODEL R-107 HS

FREQUENCY	15.7 to 16.9 KMc/s (any 2% band)	LENGTH	5.5 inches
ISOLATION	Trans-Rec, 20 db (min) Ant-Trans, 20 db (min)	POWER	100 KW (peak), 100 watts (average)
INSERTION LOSS	Trans-Ant, 0.5 db (max) Ant-Rec, 0.5 db (max)	WAVEGUIDE	Mates RG-91/U
VSWR	1.20 (max)	FLANGES	Mates UG-541/U
		SWITCHING TIME	90% switched 10 µsec (max)
		DRIVE POWER	70 watts (peak), 2 watts (average)

The L band stripline circulators are designed for medium power applications where size and weight are important.

FERROTEC, INC

MODEL T-150 L

FREQUENCY	1200 to 2000 Mc (any 10% band)
ISOLATION	20 db
INSERTION LOSS	0.5 db
VSWR	1.20 (max)
DIAMETER	7.3 inches (incl. connectors)
HEIGHT	2.1 inches
WEIGHT	2 lbs (max)

Further information on the above circulators is available by requesting engineering bulletins on each of the items.

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The ROLE *of* VENTURE CAPITAL *In the* MICROWAVE INDUSTRY

W. HARDIE SHEPARD

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Most studies indicate that the microwave segment of e electronic industry will grow at a faster rate than the ctronic industry as a whole. The over-all microwave minant portion of the industry is now estimated at ,500,000,000 annual sales, and by 1970 it is estimated at this will amount to $9,000,000,000 annual sales. me specialized areas in this broad field indicate that ere may be a 25 to 50 per cent annual growth. If this te of growth is going to materialize, it is obvious that great many companies, particularly the smaller com- nies, in the microwave industry will not be able to nance this expansion entirely through retained earnings d/or bank borrowings. These companies, therefore, ve to raise equity capital from one source or another assure themselves against losing their position in the dustry. It is a fundamental truth in this industry that a mpany has to expand to take care of the potential ture business, or competition will develop which will opardize not only the company's growth but its lvency.

A company then is faced with the choice of raising is additional equity money from either (1) an experi- nced venture capital group, (2) a single individual or o, or (3) through a small public underwriting.

The advantages of a venture capital group are con- derable for a small company. At the risk of appearing plead my own cause, let me elaborate. The majority companies in the electronic and instrumentation in- ustry are organized by technical men. They often lack, the critical early stages, executives with financial or counting experience. Such a company should be able look to a venture capital partner for all types of busi- ess and financial advice: help in the negotiation of bank rrowings, negotiation of an insurance company loan it is planning to build a new plant, or negotiation of a le and leaseback, if the company wants a new plant ilt for it and rented to it.

Experience has shown that when a substantial venture capital group is a stockholder in a company, the credit of the company is enhanced. Commercial banks, insurance companies and other lenders will more readily lend to a company with this type of backing, as they know the venture capital group will be willing to invest more money at a later date for additional profitable expansion.

The company should also be able to look to the venture capital group for help in contract negotiations, whether with the government or in subcontracts with industrial companies. It should also be able to count on help when it reaches the sales volume that makes it subject to renegotiation.

The venture capital firm will place an individual on the board of directors of such a company, one who is experienced in all of these matters. In many cases, he can act in a capacity similar to that of chairman of the finance committee in a large company.

In the electronics and instrumentation industry, a venture capital firm should not seek a majority of the stock in exchange for financing. It should be willing to take a minority position, recognizing the fact that the major contribution to the success of the company will be the scientific and technical talent that reposes in the company. The better-managed companies in this industry do not want to be dominated or controlled by a financial partner.

Another alternative is raising money from an individual or from friends. Here, as a rule, the company is only getting money. Only in exceptional cases does it get the financial advice and business help which it can expect from a venture capital group experienced in this industry. In most cases also, an individual is not in a position to put up additional money if the company continues to prosper and expand at a fast rate.

Many companies fail to comprehend the potential disadvantages which exist in resorting to a public underwriting at an early stage of their growth. This is a fairly popular form of financing at the present time, particularly for sums under $300,000. Here the company can raise money via a Form A SEC registration, which does not involve a great deal of expense other than some warrants and approximately 20 per cent selling expense by the underwriting house for raising the money.

With the stock market at a high level and with the speculative public extremely interested in the electronics and instrumentation industry, the public is often willing to pay prices which appear naturally very attractive to the issuing company. In years to come, however, these prices may not appear so attractive to the investor. A company which foresees a dynamic growth and which may have to raise additional outside capital every two or three years to retain its position, should be extremely cautious about going to a public underwriting in the early years of its growth.

The main danger is that once an issue is traded publicly, it is almost impossible to go back to the same source for additional money if the stock is selling below the price at which it was originally offered. Even though the company itself may prosper after it sells its stock issue, either the level of the stock market as a whole may drop materially, or the fickle investing public may put a lower price-times-earnings ratio on stocks in this industry.

Through no fault of its business ability, such a company may be trapped in a position where it has good future growth ahead, needs to raise additional money, but its stock is selling below the original issue price. Under such conditions it is almost impossible to raise additional money publicly. At this point, a venture capital group would be very hesitant about investing unless it was at a substantial discount to the traded market.

These conditions have forced many companies into "shotgun" mergers, which have meant loss of control to a larger company.

When a company has its stock owned publicly, it is hampered in many of the business decisions it wants to make. Take the instance when it seems appropriate to spend a substantial sum of money for a new instrument or product. This expenditure could mean that the company would have no earnings for a three or six-month period. Then the management would have serious doubts as to whether it could follow this plan, knowing that it would upset many small stockholders and the price of the stock would suffer materially.

On the other hand, if its sole outside stockholder was an experienced venture capital firm, the long-term business reasons for the proposed course of action would be viewed as much more important than whether the company was going to earn money in any particular three or six-month period.

Another disadvantage of having public stockholders before the company is large enough to have a full-time treasurer, is the fact that the technical executives of the company will have to spend an inordinate amount of time showing investment bankers and brokers through the plant and talking to a number of small stockholders. At this stage of the company's growth, the time can be spent to better advantage.

This article is not meant to infer that in all cases raising money privately is better than a public stock issue. There is a time, naturally, when it is to the company's advantage to have a public issue and where the disadvantages do not offset the advantages. This is when a company has grown to the point where it has real diversification of product and customer, and no single mistake or unfortunate business turn of events would seriously affect its over-all sales and earnings. Once a company in this industry has good diversification of both product and customer, it is ready for a dignified public issue which would be underwritten by any of the well-known investment banking firms. The company would then have a well-sponsored and active enough market in its stock to assure its long-range financial growth.

◆

RIMEA AND PUNISHMENT

At the height of the famous Charge of the Light Brigade, no less an 23 of the radar's tubes malfunctioned simultaneously. (And no nder — for this was the year 1856 — 91 years Before Bomac.) ie calamity not only left the Light Brigade totally in the dark, but it ry nearly lost the battle and the radar unit itself. Only the heroic ion of an anonymous radio operator, later reported missing, kept the it from falling into Russian hands.*

Many years later, however, there appeared in England a man named land Stone, who claimed to be the missing radio operator of Balaklava. e was given a hero's welcome and was scheduled to receive the Victoria ross for valor. He would have, too — except for a sharp-eyed, hawk-sed man named Sheerluck Domes who happened to read about Stone the newspaper. Domes rushed to see the Queen and managed to gain entrance just as Stone was about to receive his reward.

Before the startled Queen could say a word, Domes was flashing a telegraph key under Stone's nose. "If you're a radio operator," he hissed, "send me some code!" Stone stammered for a moment. His hands dropped helplessly to his sides.

"You see, your majesty!" Domes said triumphantly. "This man is no radio operator. He wouldn't know a dot from a dash if he met them in Covent Garden. Off with his head, I say."

After they had led Stone away, the Queen marveled: "But Domes, how could you be sure this man was an impostor? All you knew was his name."

"That," said Sheerluck, "was all I had to know. After all," he went on, "a man named Roland Stone simply couldn't be a radio operator."

"Why not?" asked the Queen.

"Because," the great man said, "a Roland Stone gathers no Morse."

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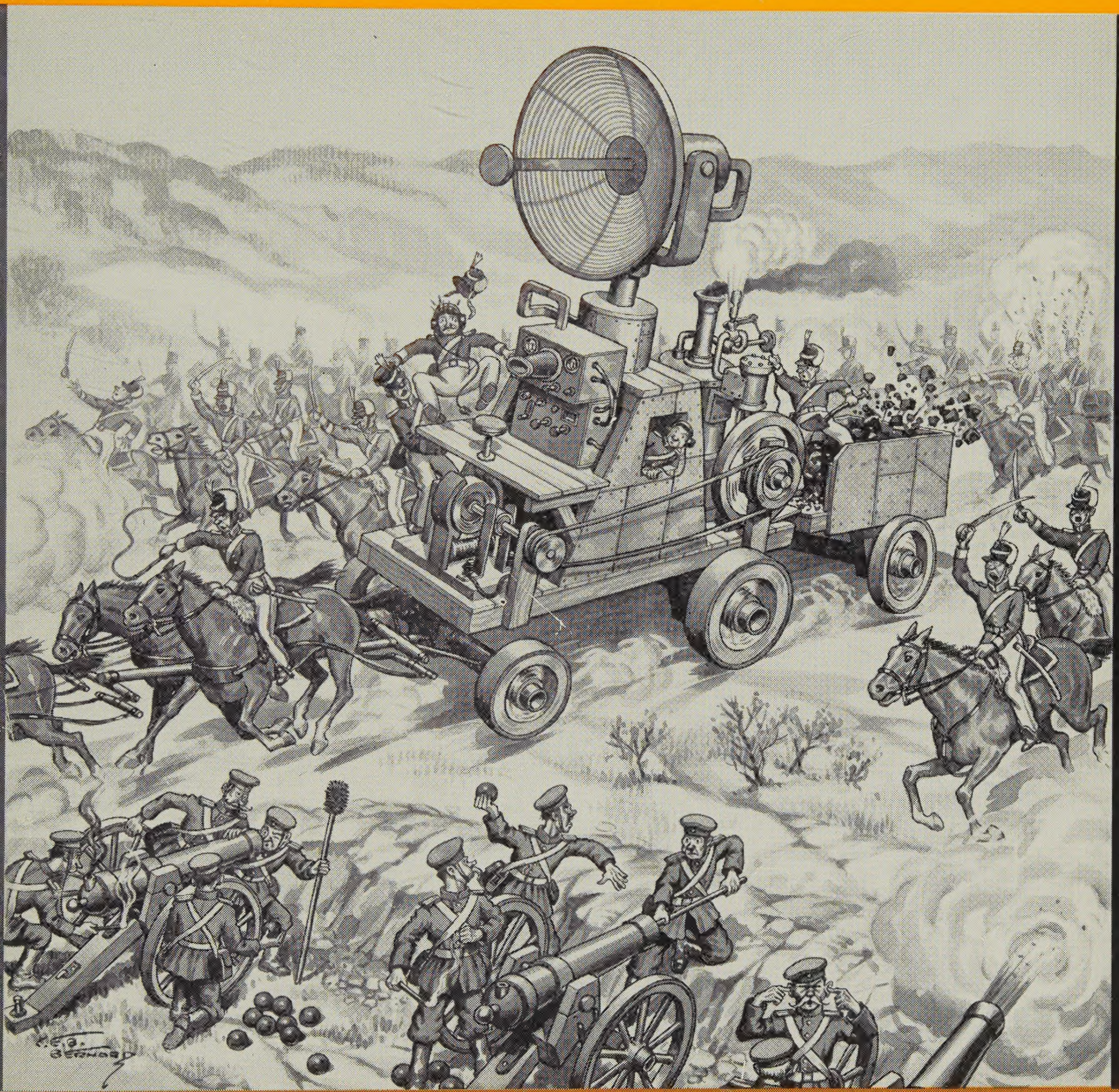

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Creative Microwave Technology

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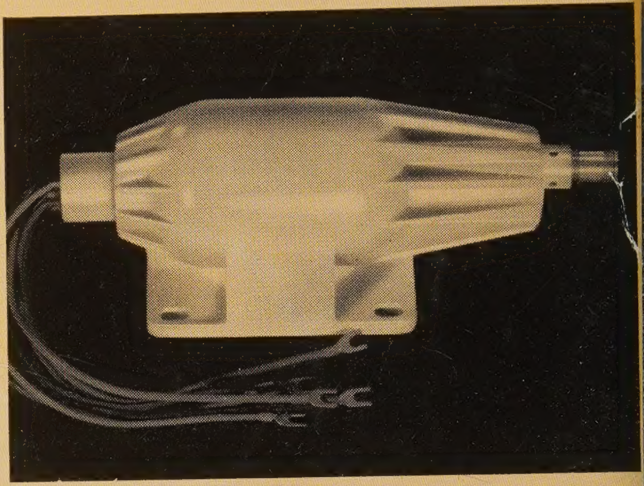
A TOTALLY NEW CONCEPT IN "O"-TYPE BWO CONSTRUCTION

--Interdigital-type delay line affords maximum heat dissipation at high power outputs

These broadband voltage tunable backward wave oscillators are the smallest, lightest and most reliable of their kind. They were developed especially for modern airborne and ground-based applications utilizing swept oscillator and frequency diversity techniques. Four compatible types are available. They cover a continuous frequency range of 1 to 12.4 KMC. They are magnetically shielded and are insensitive to the effects of external fields. They exhibit a minimum of fine-grain power output variations. Potted leads permit operation at high altitudes over a wide temperature range. Raytheon-perfected laminating techniques make possible interdigital construction which results in maximum heat dissipation. Under normal operating conditions, no forced-air cooling or protective circuitry is required. Laminate-thickness held to extremely close tolerances assures improved fine-grain frequency characteristics with optimum line matching and consistently reproducible characteristics from tube to tube.

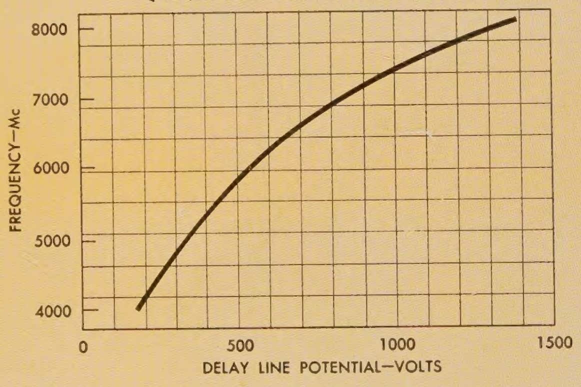


Typical Operating Characteristics

	QKB786	QKB816A	QKB760A	QKB776
Frequency Range	1.0-2.0KMC	2.0-4.0KMC	4.0-8.0KMC	8.0-12.4KMC
Power Output	100 mW Min.	70 mW Min.	30 mW Min.	50 mW Min.
Delay Line (Tuning) Voltage	100-1500 Vdc			
Filament Voltage	6.3 V.			
Cathode Current	45 mA Max.			
Anode Voltage	60-150Vdc	100-200 Vdc	60-130 Vdc	60-130 Vdc
Control Grid Cut-off	-150 Vdc	-100 Vdc	-100 Vdc	-100 Vdc

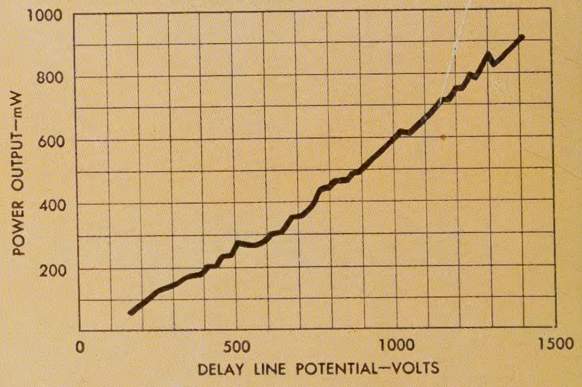
FREQUENCY VS. DELAY LINE POTENTIAL

QKB760A BACKWARD WAVE OSCILLATOR



POWER OUTPUT VS. DELAY LINE POTENTIAL

QKB760A BACKWARD WAVE OSCILLATOR



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